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- Siegman — Thermal Noise in Microwave Systems — Part I
- Rosenblum — Atmospheric Absorption of 10-400 kMcps Radiation: Summary and Bibliography to 1961
- Wilkinson — A Circularly Polarized Slot Antenna
- Benderly & Kilduff — A Teflon Microwave Window

the microwave journal

ROBERT H MAIER
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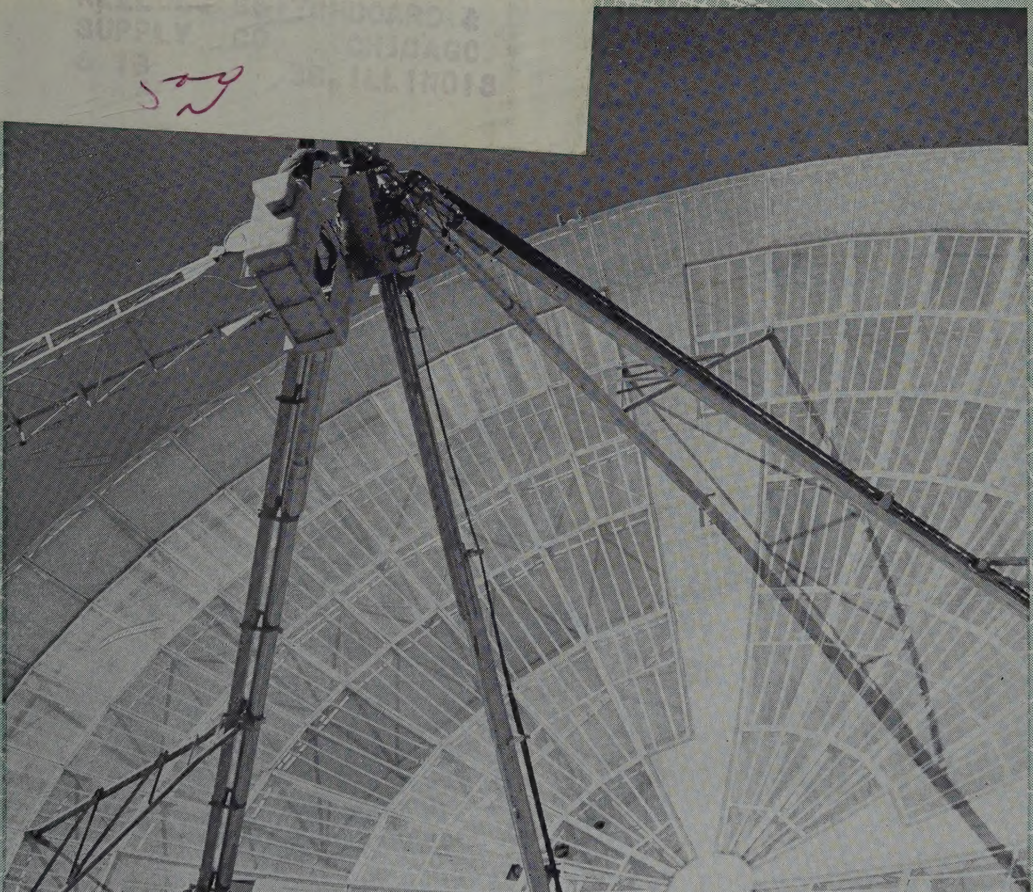
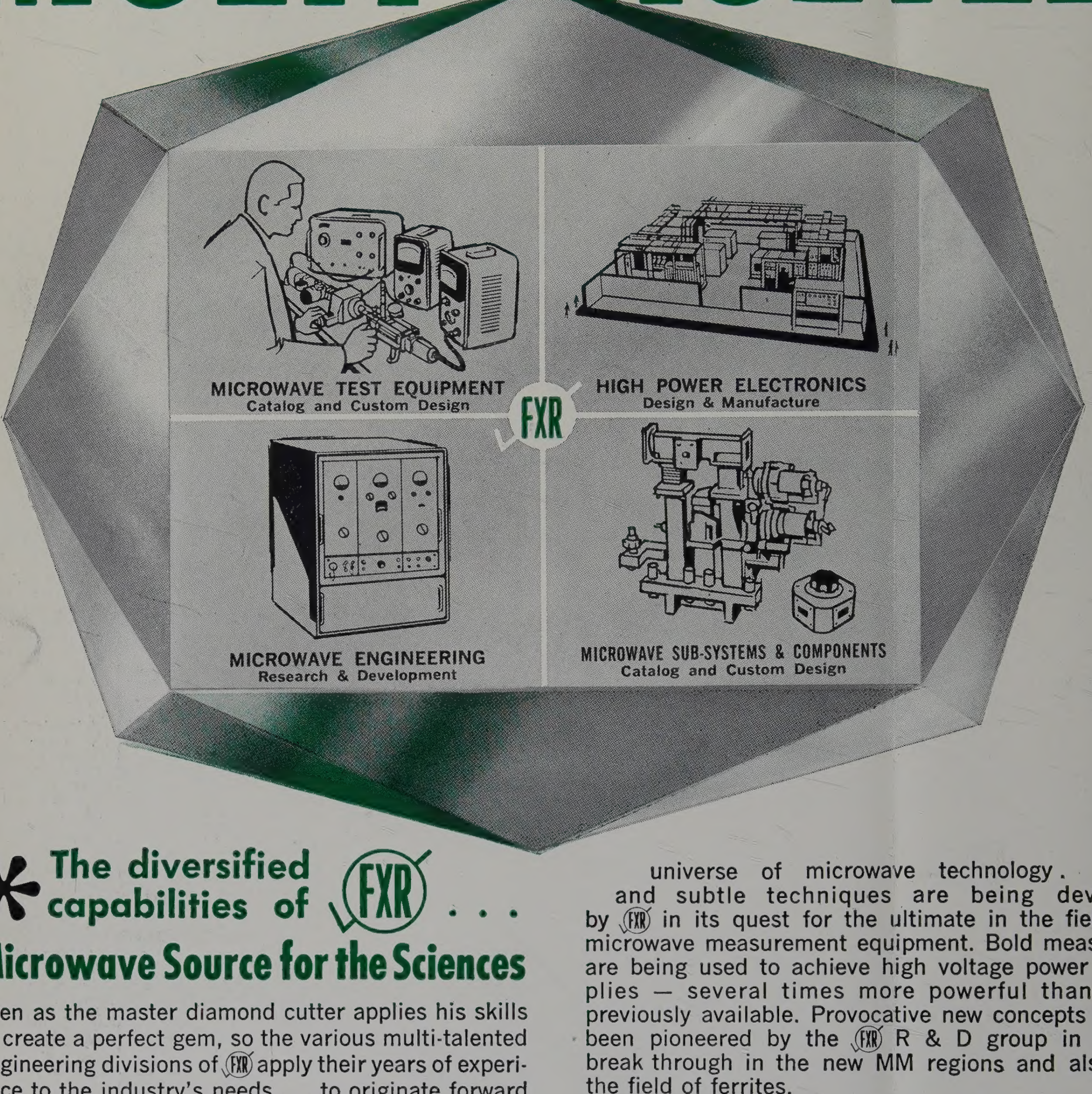


In This Issue . . .

THERMAL NOISE IN MICROWAVE SYSTEMS — PART I

MULTI-FACETED*


MICROWAVE TEST EQUIPMENT
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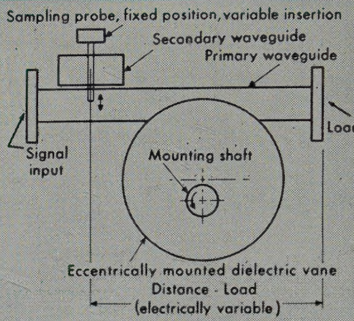
Infinite care in producing all the FXR 2- and 3-mm waveguide components is exemplified by:

- Components machined and milled as needed out of solid blocks.
- All components internally gold plated to preserve their low insertion loss features.
- Precision differential screw micrometer drives (readable to ±0.001 millimeters) used for FXR G band Frequency Meters and Precision Sliding Shorts.

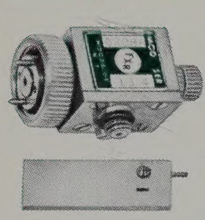
TYPE
G105A
FXR
SERIAL
111
20

FXR G105A SLOTTED SECTION



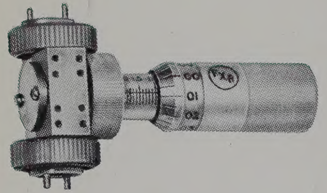
- Frequency Range: 140-220 KMC/sec
- Novel technique (see drawing) incorporates a fixed position probe and an adjustable phase shifter to sweep VSWR pattern past the probe.
- Recommended accessories:
  FXR G208A Detector Mount and Crystal

FXR also has available the most complete line of mm waveguide components for use in the 18 KMC to 90 KMC region.



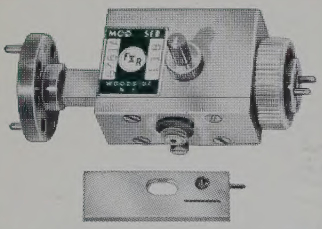
FXR G208A DETECTOR MOUNT WITH
FXR Z224A CRYSTAL DETECTOR CARTRIDGE

- Frequency Range: 140-220 KMC/sec
- In-guide detector elements for maximum sensitivity
- Series 208 Detector Mount can be used with replaceable crystal, bolometer, or thermistor cartridges
- Recommended accessories:
  FXR Z224A Crystal Detector Cartridge
  FXR Z230S Bolometer Cartridge
  FXR Z235S Thermistor Cartridge



FXR G412A FREQUENCY METER

- Frequency Range: 140-220 KMC/sec
- Micrometer dial, calibration chart supplied provides an accuracy of ±0.5%. Specific point accuracy ±0.2%.
- Self-calibrating by using successive resonances



FXR G781A HARMONIC GENERATOR WITH
FXR Z225S
HARMONIC GENERATOR CARTRIDGE

- Provides second harmonic output signal in the frequency range 140-220 KMC/sec when supplied with a fundamental frequency input signal
- Required accessory:
  FXR Z225A Harmonic Cartridge

These components are also available in the FXR F band (90 to 140 KMC)

2 & 3-mm waveguide components

FXR SERIES PREFIX WAVEGUIDE SIZE IN INCHES (I.D.)	F .080 x .040	G .051 x .0255
FREQUENCY RANGE IN KMC/SEC	90.-140.	140.-220.
SLOTTED SECTIONS	F105A $1400	G105A $1400
ATTENUATORS—Precision Calibrated	F163A $ 975	G163A $ 975
CRYSTAL DETECTOR MOUNTS—Tuneable	F208A $ 400	G208A $ 400
CRYSTAL DETECTOR CARTRIDGE	Z224S $ 150	Z224S $ 150
HARMONIC GENERATOR	F781A $ 475	G781A $ 475
HARMONIC GENERATOR CARTRIDGE	Z225S $ 150	Z225S $ 150
BOLOMETER CARTRIDGE	Z230S $ 150	Z230S $ 150
THERMISTOR CARTRIDGE	Z235S $ 150	Z235S $ 150
TUNERS—E/H	F313A $ 775	G313A $ 775
PRECISION PHASE SHIFTERS	F314A $ 950	G314A $ 950
FREQUENCY METERS—Reaction, micrometer	F412A $ 750	G412A $ 750 G413A $ 800
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WAVEGUIDE TEES—Series	F620A $ 275	G620A $ 275
Shunt	F621A $ 275	G621A $ 275
Hybrid	F622A $ 325	G622A $ 325
WAVEGUIDE BENDS—90° E-plane	F623A $ 275	G623A $ 275
90° H-plane	F624A $ 275	G624A $ 275
WAVEGUIDE 90° TWISTS	F625A $ 100	G625A $ 100
PRECISION SLIDING SHORTS	F631A $ 275	G631A $ 275
STRAIGHT WAVEGUIDE SECTIONS (Min. length)	F634A $ 85	G634A $ 85
STANDARD GAIN HORNS	F638A $ 200	G638A $ 200

Characteristics and prices subject to change without notice.

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and . . . The Application of Recently Obtained Scientific Data

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- Data processing and display circuits for advanced concepts in ground based communication and radar systems.

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MARCH, '61 vol.4 - no. 3

the microwave journal

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The Lincoln Laboratory Antenna Test Range

Thermal Noise in Microwave Systems — Part II

Standardization of Ridged Waveguides

A Simple Approximate Expression for Converting Directly from Noise Figures in db to Noise Temperatures

Measuring High Power Breakdown

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accuracy

IN HIGH POWER RANGES

water loads

FROM VARIAN ● ● ● ● ● ● ● ●

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Varian water loads terminate high or low power systems in both pressurized and unpressurized transmission lines, and operate either pulsed or CW. Extremely low VSWR.

The V-4044 is the newest addition to Varian Associates' large family of water loads. Average power 75 kW, frequency 750 to 1250 Mc. Other water loads are available from 0.40 kMc to 12.4 kMc, and at average power ratings from 5 kW to 30 kW. Special loads to custom specifications.

V-4044 Characteristics:

Frequency . . . 750 to 1250 Mc

Power . . . 75 kW

VSWR . . . less than 1.15

Waveguide Size... WR 975

V-4044 water load ready for shipment

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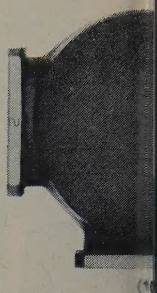
For technical data on Varian water loads, write Radiation Division.

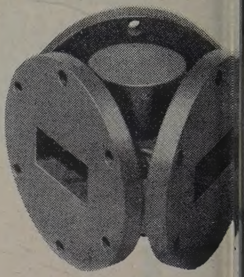
For the most advanced ferrite devices—try Hughes!


(1
X-band C
Low Pow

Now available at firm prices and in production quantities, Hughes ferrite devices are among the most advanced components of their type on the market today. Their reliability and advanced design are the result of Hughes pioneering efforts in ferrite device research, development and production.

Whatever your particular systems design problem, it is likely Hughes engineers can help you solve it. For engineering assistance or to order Hughes ferrite devices, write, wire or call: Hughes Components Division, Marketing Operation, Culver City, California. TWX HAC SMON; Phone UPton 0-7111, Ext. 4190.

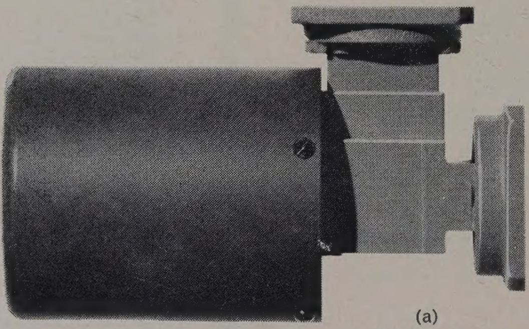
Typical ferrite devices offered by Hughes:
(In addition to these standard models, modified or custom designed units to meet your specific requirements can be provided.)

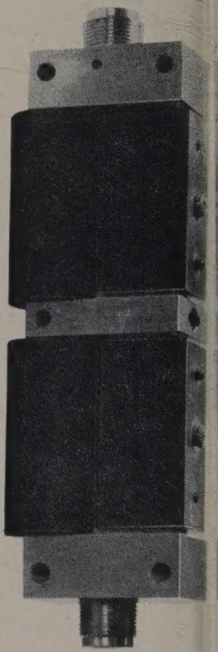

(d)
C-band Circulator,
Low Power, Wye

HUGHES

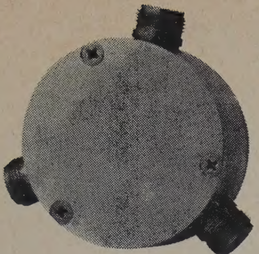
HUGHES AIRCRAFT COMPANY
COMPONENTS DIVISION

(b)
X-band Circulator,
High Avg. Power, 4-Port

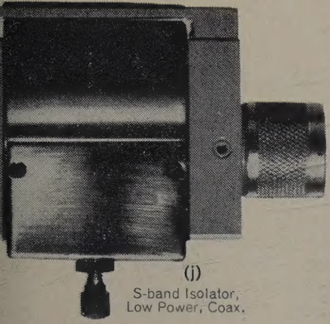

(a)
X-band Switch,
Hi-speed


(c)
S-band Isolator,
Low Power Coax.

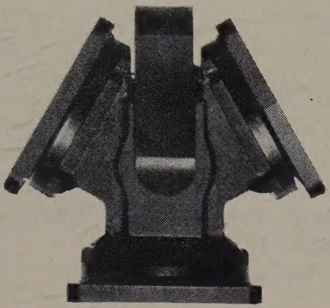
SPECIFICATIONS	(a) X-band Switch, Hi-speed	(b) X-band Circulator, High Avg. Power, 4-Port	(c) S-band Isolator, Low Power Coax.	(d) C-band Circulator, Low Power, Wye	(e) X-band Modulator	(f) X-band Circ Low Power
Frequency Range	8400-9600 mc	8400-9600 mc	2190-2310 mc (tunable) (20 mc bandwidth)	4900-6200 mc	8500-9500 mc	8000-980
Isolation	30 db min.	25 db min.	50 db min.	20 db min.	—	20 db mi
Insertion Loss	0.75 db max. (Switching time .2μ sec.)	0.5 db max.	1.0 db max.	0.5 db max.	0.5 db max. (Atten. range—25 db min.)	0.5 db m
VSWR	(on) 1.5 max.	1.2 max.	1.1 max.	1.2 max.	(input) 1.5 max.	1.2 max.
Power Capacity Peak Average	 10 kw 50 watts	 300 kw 5 kw	 5 kw 10 watts	 3 kw 15 watts	 2 kw 1 watt	 2 kw 10 watts
Model Number	1011-A	1015-A	1007-A	1003-A	1014-A	1002-A &



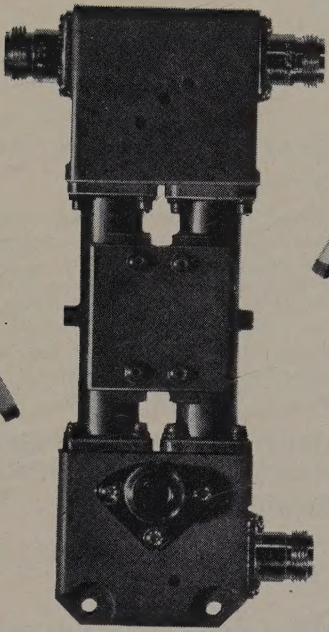
(h)
S-band Circulator,
Med. Power, Coax. Wye



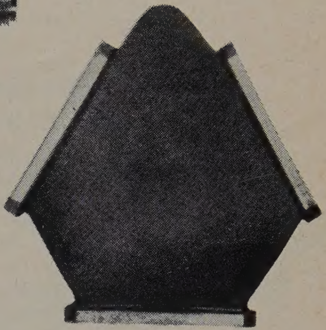
(j)
S-band Isolator,
Low Power, Coax.



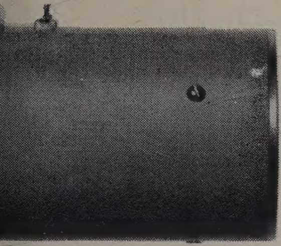
(k)
X-band Circulator,
Low Power, Wye



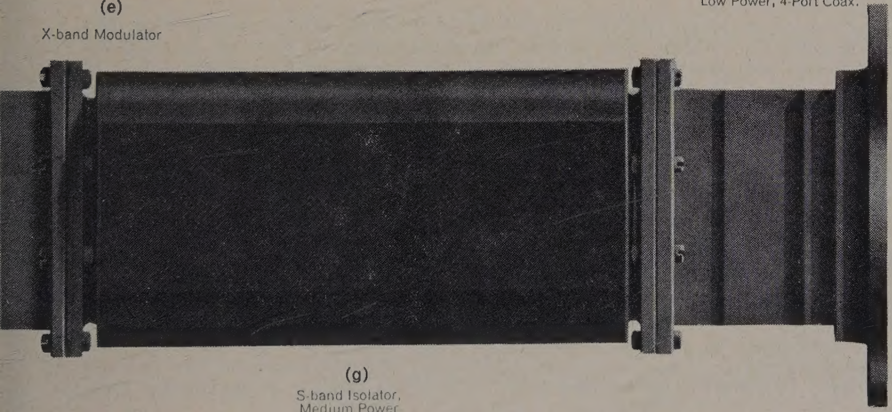
(i)
S-band Circulator,
Low Power, 4-Port Coax.



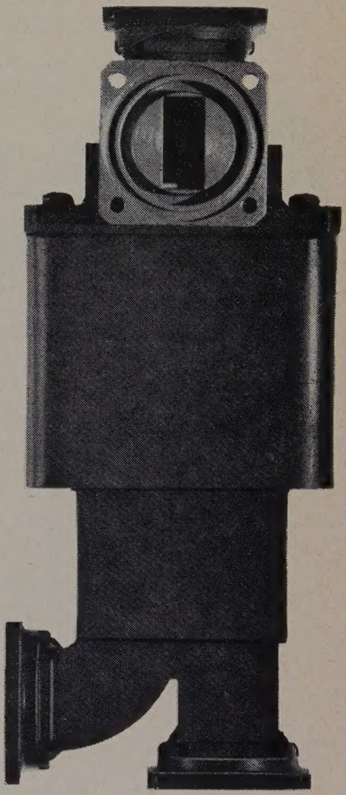
(l)
X-band Circulator,
Low Power, Wye



(e)
X-band Modulator



(g)
S-band Isolator,
Medium Power



(m)
X-band Circulator,
Hi-power, 4-Port

(g) S-band Isolator, Medium Power	(h) S-band Circulator, Med. Power, Coax. Wye	(i) S-band Circulator, Low Power, 4-Port Coax.	(j) S-band Isolator, Low Power, Coax.	(k) X-band Circulator, Low Power, Wye	(l) X-band Circulator, Low Power, Wye	(m). X-band Circulator, Hi-power, 4-Port
2600-3700 mc	2700-2900 mc	2600-2900 mc	2700-2900 mc (tunable) (30 mc bandwidth)	8000-9800 mc	7100-8700 mc	8400-9600 mc
10 db min.	20 db min.	20 db min.	25 db min.	20 db min.	20 db min.	25 db min.
0.5 db max.	0.5 db max.	0.3 db max.	0.5 db max.	0.5 db max.	0.5 db max.	0.4 db max.
1.3 max.	1.25 max.	1.25 max.	1.1 max.	1.2 max.	1.2 max.	1.15 max.
300 kw 100 watts	25 kw 25 watts	— 500 mw	5 kw 10 watts	2 kw 10 watts	3 kw 15 watts	300 kw 400 watts
1013-A	1012-A	1005-A	1008-A	1001-A & AA	1009-A	1004-A

See these ferrite devices at the Hughes Booth (1315-17) at the IRE SHOW.

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MICROVIEWS

OF THE MONTH

81 ▶ THERMAL NOISE IN MICROWAVE SYSTEMS — Part I

A. E. Siegman

This tutorial article on thermal noise in microwave systems comes from a graduate course taught by the author at Stanford University. The same material will also appear as a chapter in a book on "Solid-State Masers" by the author, to be published later by McGraw-Hill. The article will appear in "the microwave journal" in three parts. Part I, in the present issue, discusses some fundamental aspects of thermal noise in electrical circuits. Part II, in the following issue, will discuss the performance of high-frequency amplifiers, particularly maser amplifiers. Part III will be concerned with practical problems in low-noise amplifiers, and also with the ultimate quantum limitations on amplifier noise figures.

91 ▶ ATMOSPHERIC ABSORPTION OF 10 - 400 kMcps RADIATION: SUMMARY AND BIBLIOGRAPHY TO 1961

E. S. Rosenblum

A summary is given of the theory and experimental data on absorption of microwaves by atmospheric water vapor and molecular oxygen. A rather complete bibliography is included.

97 ▶ A CIRCULARLY POLARIZED SLOT ANTENNA

E. J. Wilkinson

This paper considers an antenna system consisting of a tilted dipole mounted in the aperture of a slot radiator. Either the slot or the dipole may be excited directly by the feed line with the remaining element being excited by parasitic action only. If the tilt angle of the dipole and the reactance terminating the parasitic element is properly adjusted, circular polarization can be realized. A theory of operation is presented along with experimental results.

101 ▶ A TEFLON MICROWAVE WINDOW

Asaf A. Benderly and Timothy J. Kilduff

A 0.005 inch thick Teflon (DuPont polytetrafluoroethylene) film was treated in a sodium-naphthalene bath to render it cementable and was then bonded to aluminum or magnesium wave guide flanges with a newly developed high temperature resistant adhesive containing epoxy resin and solvent. Windows so assembled successfully withstood pressures of at least 24 psig at a temperature of 125°C for 15 minutes. The insertion of these windows in a microwave test-assembly did not increase the voltage standing wave ratio (VSWR) beyond 1.08 when measured within a particular test-frequency band.

Sealed glass or mica windows generally cost several dollars; this type of cemented Teflon window can probably be produced for a small fraction of this cost.

OUR COVER

The airborne engineer shown on the cover is preparing to transfer liquid helium into a 960 Mc/s solid-state maser amplifier recently installed by the California Institute of Technology's Jet Propulsion Laboratory on an 85′ diameter parabolic antenna located at Goldstone, California. The increasing use of ultra-low-noise amplifiers such as masers has made possible receiving systems with noise temperatures of only a few degrees Kelvin, and has focused attention on the practical problems of such low-noise systems. See page 81.

Photograph Courtesy
Jet Propulsion Laboratory

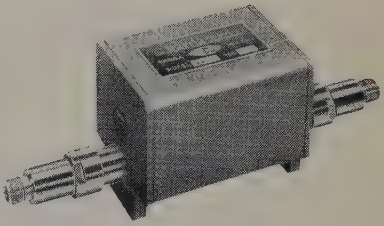
the
microwave
journal

new! NARDA ferrite isolators

designed and manufactured by NARDA MICROWAVE!

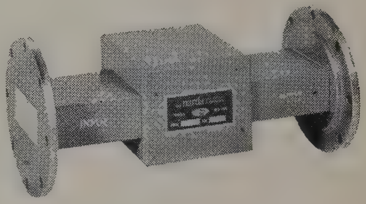
• broadband coaxial ferrite isolators

Excellent electrical characteristics with extreme versatility! ⅞″ coaxial line construction allows higher power operation with ⅞″ connectors, up to 20 kw peak, 400 watts average. (Normally supplied with Type N, ⅜″ connectors; 10 kw peak, 10 watts average.) Features 15 db isolation and 1 db max. insertion loss. VSWR is 1.25 max. based on 2:1 load mismatch; 1.15 max. into matched load. Model 1233: 2.0—4.0 kmc; model 1233-1: 3.0—5.5 kmc; $450. each.



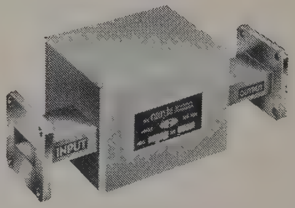
• low power broadband waveguide ferrite isolators

Provide maximum load isolation and minimum insertion loss over full standard waveguide frequency ranges. Extremely useful for maintaining signal source stability and eliminating long line and frequency pulling effects. Front-to-back ratios are the highest available on the market today: C Band—26:1, $250; XN Band—28:1, $225; XB Band—60:1, $235; X Band—30:1, $220.



• high power broadband waveguide ferrite isolators

The only line of high power isolators that covers all of X Band with just two models (8.2-10.0 kmc and 10.0-12.4 kmc), each with front/back ratio of 40:1. Input power rating: 250 kw peak, 300 watts average, achieved through use of special high Curie temperature ferrite materials. VSWR is 1.05 max. with matched load; 1.10 max. with 3:1 mismatch. Only $175 each. Model with same VSWR, 28:1 front/back ratio, 300 kw peak, and 300 watts average, for 7.05-10.0 kmc, $195.



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ON DISPLAY AT THE IRE SHOW!

From the editor

THE UNIVERSITY OF NEBRASKA

Recently I had the pleasure of spending a day at the University of Nebraska in Lincoln, Nebraska, as the guest of Dr. Clyde M. Hyde, Acting Chairman of the electrical engineering department.

The situation there is probably typical of the situation at many other fine schools throughout the country.

Here is a large school with a relatively small but enthusiastic electrical engineering department. It is far removed from any industrial organization that might help to provide a well rounded picture of electronics (or microwaves) not just as part of the curriculum, but also as a business. It is far removed from any industrial organization that could both draw on the University for talent and information and at the same time provide engineering jobs in the local area, and thereby help broaden the total experience of the department.

Dr. Hyde and his colleagues are fully aware of the need for the industrial touch and hope that a solution will be forthcoming in the near future. They feel that one day some company involved in some aspect of electrical engineering (they hope for microwaves or solid state) will establish itself or one of its divisions in or near Lincoln. Further, they believe that once the first company moves in, others will follow.

Although my visit was short, it opened my eyes to one possible way of helping to reduce the engineering shortage. Here is a small group that might grow appreciably in size and scope, if it were provided with the type of stimulus to be derived from the proximity and interest of some of our more capable industrial concerns. The work they are doing in the laboratories and the courses they are teaching are excellent. The students that I met not only had a keen sense for microwaves, but they had a refreshing degree of enthusiasm.

One other problem they have, which is much easier to solve, is the need for miscellaneous microwave gear. They have in the laboratories most of the basic test equipment. However, they could use all sorts of extra pieces of coax or waveguide. Every company has at least one barrel filled with what to them are useless sections of plumbing.

One of the smartest things that those of us in industry could do to help ease the microwave engineering shortage might be to send, not only to the University of Nebraska but to other schools, such equipment that we no longer use. This might include slightly damaged waveguide or coax components, some of our rejects, or even miscellaneous test equipment that is obsolete or in need of repair. Much of it would be valuable to most engineering schools.

This would then enable the students to do more microwave work in the laboratory without straining the budget.

I believe this plea was made some years ago. It is still an important idea, one that we would like to promote and encourage. Some companies have already contributed much in this area, but there are many others who could also help.

Ted Saad

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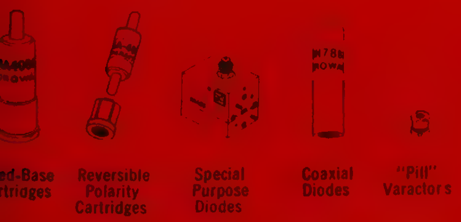

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	UHF BAND CUL SERIES	L-BAND CLL SERIES		S-BAND CSL SERIES
Frequency Range	800-1000 Mc	1000-1700 Mc	1700-2400 Mc	2400-4000 Mc
Bandwidth	Any 10% band	Any 10% band	Any 10% band	Any 10% band
Isolation	20 db min. 35 db max.	20 db min. 35 db max.	20 db min. 35 db max.	20 db min. 35 db max.
Insertion Loss	0.3 db min. 0.5 db max.	0.2 db min. 0.4 db max.	0.2 db min. 0.4 db max.	0.2 db min. 0.4 db max.
VSWR	1.25 max.	1.25 max.	1.25 max.	1.25 max.
Power (Average)	5 watts	5 watts	5 watts	5 watts
Power (peak)	5 kw[2]	5 kw[2]	5 kw	5 kw
Weight (max.)	4.8 lbs.	3.3 lbs.	2.3 lbs.	11 oz.
Diameter (max.)[1]	6⅛ in.	2½ in.	2½ in.	1¾ in.
Height	3¼ in.	4 in.	2½ in.	1⅝ in.
Connectors	Type N	Type N	Type N	Type N
Temperature Range[3]	T_0 ±20°C	T_0 ±20°C	−40°C to +60°C	−40°C to +60°C

[1] Excluding Connectors

[2] Up to 100 kw is possible with Type HN connectors

[3] T_0 is 25°C unless otherwise requested

New miniature broadband circulators for UHF, L & S band

Now, Raytheon introduces compact, lightweight, three-port circulators with extremely low insertion losse

Miniaturized Raytheon coaxial line circulators f UHF, L- and S-bands now are available with is lations of 20 db and insertion losses of .5 db an less!

The L- and S-band units—in production just months after Raytheon announced the first coaxi ferrite circulator to the microwave industry—c be mounted directly to steel structural membe without any separation or shielding. Maximu dimensions are 1¾ inches for S-band, 4 inch for L-band and 6⅛ inches for UHF models. combination of any two of the units can be pac aged for a highly efficient 4-port circulator.

To learn more about these significant develo ments and other circulators now available dov to 400 Mc and up to 6000 Mc with similar cha acteristics, please write, stating your particul area of interest, to the following addres Raytheon Company, Special Microwave Devi Operations, Waltham Industrial Park, Waltha 54, Massachusetts. In Canada, contact Raythe Canada Limited, Waterloo, Ontario.

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" . . . taking an unformulated enterprise"

" . . . and making it into what it could become."

MICROWAVE PEOPLE

DR. FREDERICK EMMONS TERMAN

Vice President, Provost
Stanford University

By ADELAIDE PAINE

Certainly if Marconi was the father of the telegraph, rederick Emmons Terman is Grand Vizier of the age of lectronics—a man who took the scattered, cumbersome ieces of early electronics and formulated them into an nderstandable whole with his "Radio Engineering" and Radio Engineer's Handbook." He has gone through ife making what was static, electric; what seemed imossible, possible.

After radio theory was between covers, he organized Harvard Radio Research Laboratory during he beginnings of World War II at the request of the overnment. The only answer he could get to his query f what this laboratory was expected to do came from an dmiral who said, "We don't know. That's why we hired ou, to find out what to do, and then to do it." With hat for an answer, Dr. Terman gathered together all vailable manpower and by the end of the war had helped o develop 150 electronic countermeasure devices, repreenting 300,000,000 dollars worth of war production.

After the war, he again had the vision to see that here would be a continuing relationship between govern-nent and universities in research that might well be conlucted in a manner profitable to both in peacetime. With his new concept in mind, he helped develop Stanford University into one of the biggest engineering centers in the country.

Frederick Emmons Terman is not only strongly identified with the old electronics and the new, but also with Stanford's 9000 acres from which so much of it is springing. He is now entering his 49th year as a Stanford campus resident, having come there as a child in 1912 when his father, Lewis Terman, the psychologist, taught there. "As a young boy I was interested in natural science," Dr. Terman commented. "I used to hike all over the Stanford hills looking for insects and rocks. Then I became interested in 'wireless' as it was then called, and in 1916 got my first ham station license with the call of 6FT."

Dr. Terman himself is a large man with a craggy face and a slight, scholarly stoop who settles into a chair with the same permanence with which he has settled into Stanford University life. And there is the warmth of a long-time love affair in his smile as he reminisces over his early days on campus.

"Three of us had a community amateur radio station in the early twenties. Jack Franklin was chief operator, Herbert Hoover Junior was apparatus builder, and I was

(*Continued on page 14*)

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We use a special ferromagnetic compound in these units. Result: improved unidirectivity.

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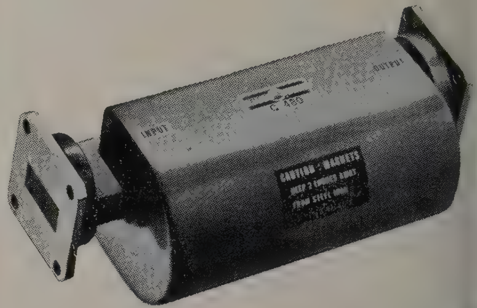

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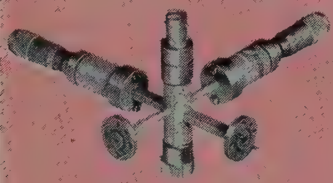

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—the finest money can buy, offering precise resettability . . . micrometer depth control . . . VSWR as high as 20/1, as low as 1.02 . . . micrometer readout to .0001″.

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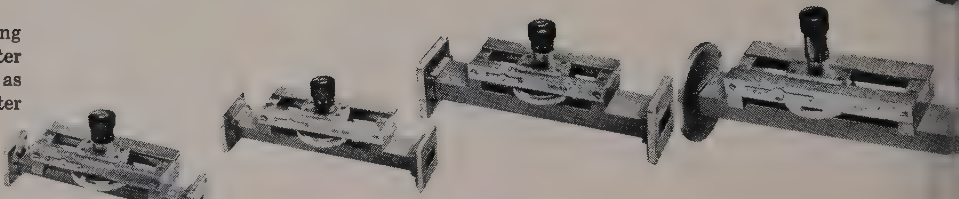

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This line—the most widely used in America today—has opened new horizons in microwave applications. If you are interested in higher and higher frequencies, get in touch with us—we're now working with frequencies up to 300 KMC/sec.

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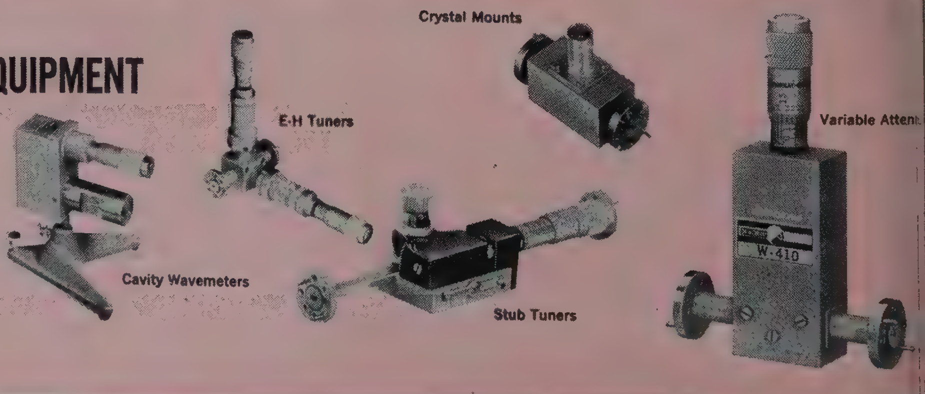

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ANSWER: By act of congress, the U.S. Bureau of Standards determines the primary standard, based on the revolution of the earth. Our unique design, methods, and environmentally controlled calibration procedures enable us to deliver production cavity wavemeters calibrated to an accuracy of 1 x 10^{4}. Transfer of frequency calibration from U.S. Bureau of Standards data is accomplished well within the limits defined.

Exclusive features:

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This offer holds good for orders placed until the end of the month following publication of this issue.

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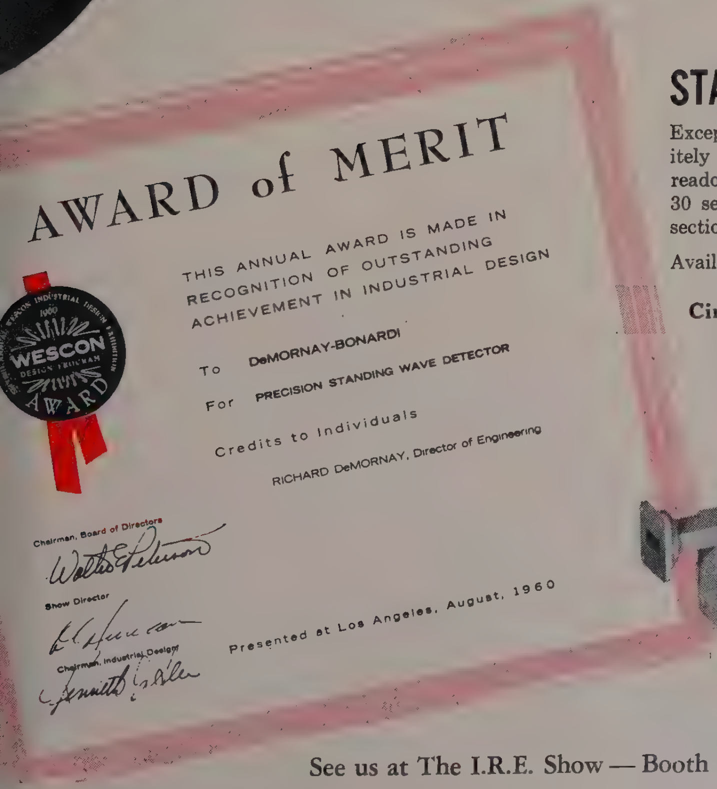

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Available from 5.8 KMC to 300 KMC.

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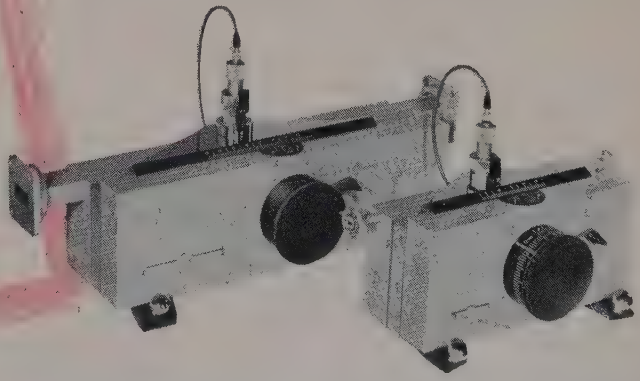

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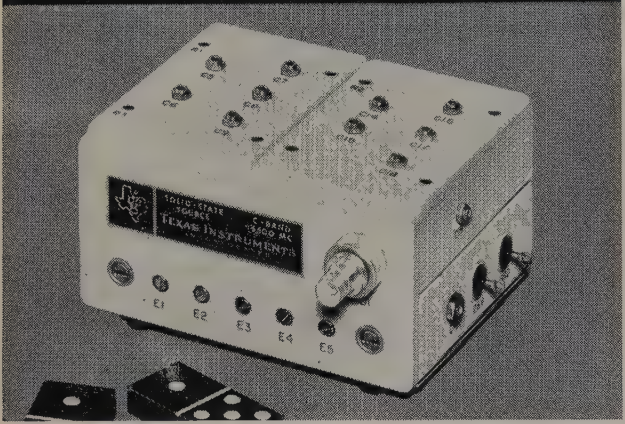
from 30 mc to 10 kmc!



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Solid-state microwave sources from Texas Instruments now give you a small, light-weight, reliable means of generating crystal-controlled, low-power microwave signals. Designed with TI XD-500 gallium arsenide diodes, these devices can be used wherever reliable, fixed-frequency, r-f sources are needed; for example, local oscillators, parametric amplifier pumps, higher frequency telemetry transmitters, microwave transmitter exciters, laboratory and portable field test signal generators and frequency standards, and phase-locked oscillators. Modular construction lets you add new frequencies by "stacking," or modify frequencies by changing multiplier units. Sources for your special needs can be supplied by modifying standard TI designs.

TYPICAL SOLID-STATE SOURCE CHARACTERISTICS	
frequency accuracy	Crystal, Standard models 0.005%
frequency stability	0.005%
band pass	1% to 5% up to 3 kmc Less than 1% above 3 kmc
spurious frequencies	Down 30-40 db
output impedance	50 ohms
primary power requirements	28 v dc positive; power requirements, 1-20 watts depending on frequency and power output; 28 v regulated power supply operating from 115 v 60 cps or 400 cps can be provided.

Harmonic generators — to frequency multiply existing power outputs to frequencies as high as 20 kmc — are also available. For details on TI's Solid-state microwave sources and harmonic generators, write for Bulletin No. DLA-1218. For information on other microwave devices contact MARKETING DEPARTMENT.

APPARATUS DIVISION
TEXAS INSTRUMENTS
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P. O. BOX 6015
DALLAS 22, TEXAS

TERMAN

(Continued from page 11)

'consulting' engineer," he chuckled. "My call was then 6AE, the fifth call issued in this district after World War I. Later we got a new call, 6XH. With our spark rig on 200 meters, we talked regularly to Los Angeles and Phoenix. We occasionally even talked to Denver.

"In 1922, Hoover built some small tube transmitters. He enjoyed the building more than the operating of the equipment. He and Jack Franklin later went to work for Western Air Express, which is now TWA, and persuaded them to put the first radiotelephone equipment in airlines back in 1927."

At this point Dr. Terman brought out an early communication from the Department of Commerce, Office of Radio Inspector, San Francisco, pertaining to a violation in operating station 6AE which is most amusing in light of present F.C.C. regulations. It was dated March 23, 1921. It read:

"Sir:

It has been found that the wave length of the energy emitted by your radio transmitter exceeds considerably the legal limit of 200 meters. The wave is also excessively broad. You will not, therefore, again operate your transmitter until it has been tuned and adjusted to a wave length of 200 meters or below, and with a decrement of .2. Kindly notify this office when the station has been adjusted and further instructions will be issued to you."

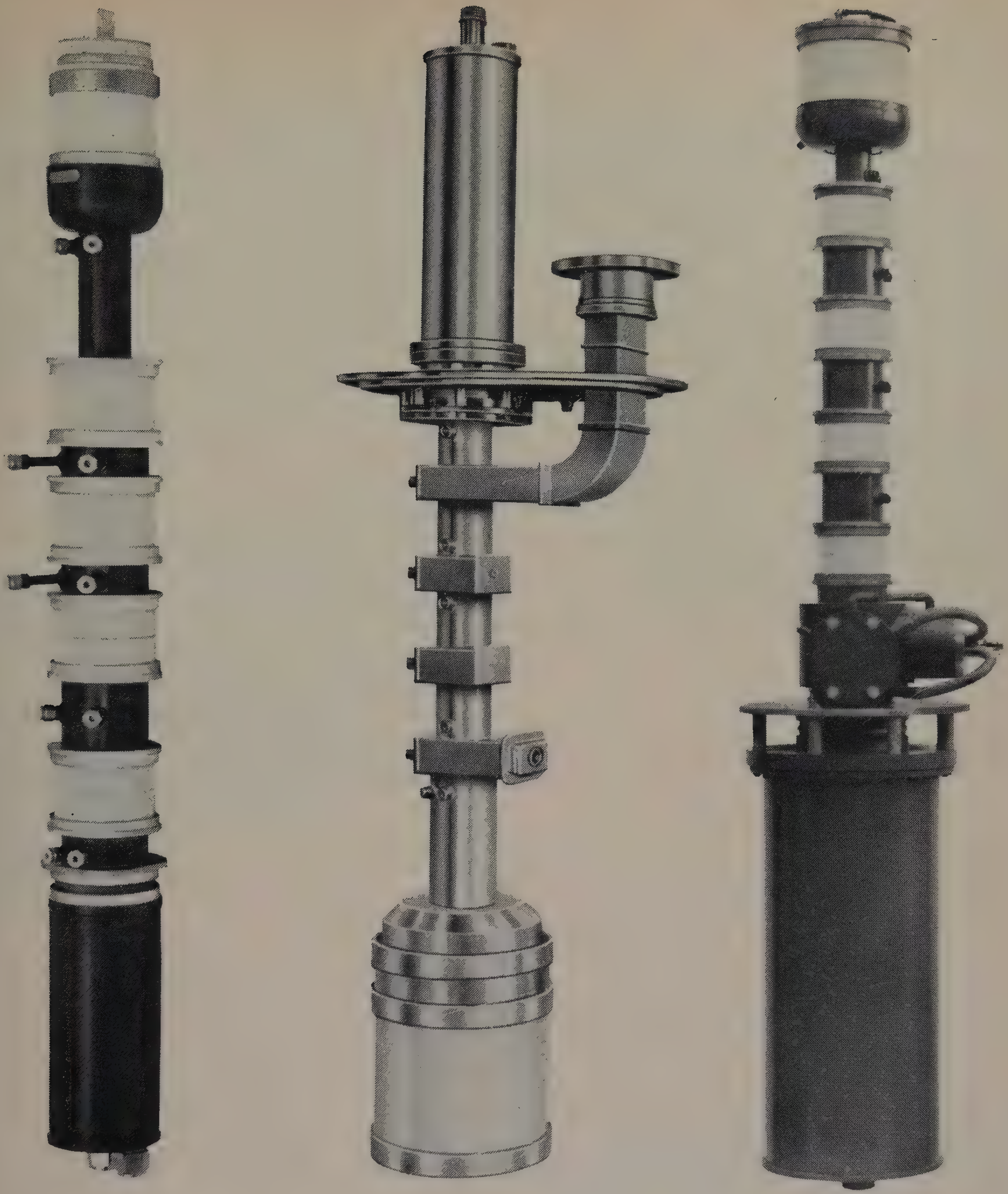
Dr. Terman continued, "I didn't have as much time for radio as Hoover and Franklin did, as I was busy getting through college." When I inquired as to why he'd taken his AB degree in chemical engineering, he explained that electrical engineering was half mechanical engineering as taught at Stanford in those days. "Besides, I thought the chemistry laboratories were more interesting than the mechanical shops, but I always intended to do my graduate work in the electrical field," he added.

He studied at MIT for his doctorate under Vannevar Bush, doing his thesis on "Electrical Power Transmission Lines". "It was Bush who put applied mathematics into engineering," Dr. Terman remarked at this point.

After getting his doctorate, Dr. Terman returned to California for a vacation and found he was suffering from a case of tuberculosis. "It was during that year of prescribed 'inactivity' that I first began to see that all of the electrical theory I had been exposed to during the preceding years could be used to get quantitative answers to the many questions that had earlier bothered me about radio, and first thought about putting it in written form. I even read Morecroft's encyclopedic book on radio right through from page one to page one thousand." He smiled. "I'm sure no one else can say they've ever done that.

"I found that the work I'd had up to then in high voltage at Stanford, in advanced circuit theory and transmission lines at MIT under Bush and Kennelley, could all be applied to radio. And after my recovery, I taught the first course in radio engineering given at Stanford, this in the spring of 1926.

(Continued on page 17)



here are 3 ways to design a klystron. Which is best?

e answer: there is no *one* best way. The design of a tron must vary to meet specific performance requirements. instance:

the 4K50,000LQ, left, *external-cavity* design is best for ducing 10 kw power output at 755-985 Mc. (Proof: more 25,000 hours of near unattended service in troposcatter ems!)

the 4KP40,000SQ, center, *internal-cavity* design is best developing 10 Mw pulse output power at 2845-2865 Mc. oof: better than 2,500 hours in continuous rf service!)

the 5K210,000LQ, right, a *combination* of internal and external design is best for achieving 75 kw minimum average power output at 755-985 Mc. (Proof: tested to 100 kw!)

Where will you find klystrons designed all three ways? Where will you find *every* klystron always shaped the best way to meet specific needs? *Only* at Eimac... where unmatched tube-making skills permit complete design flexibility. For more facts, more figures, get your free copy of "Advancing Klystron Performance Through Design Freedom." Write: Eitel-McCullough, Inc., San Carlos, California.

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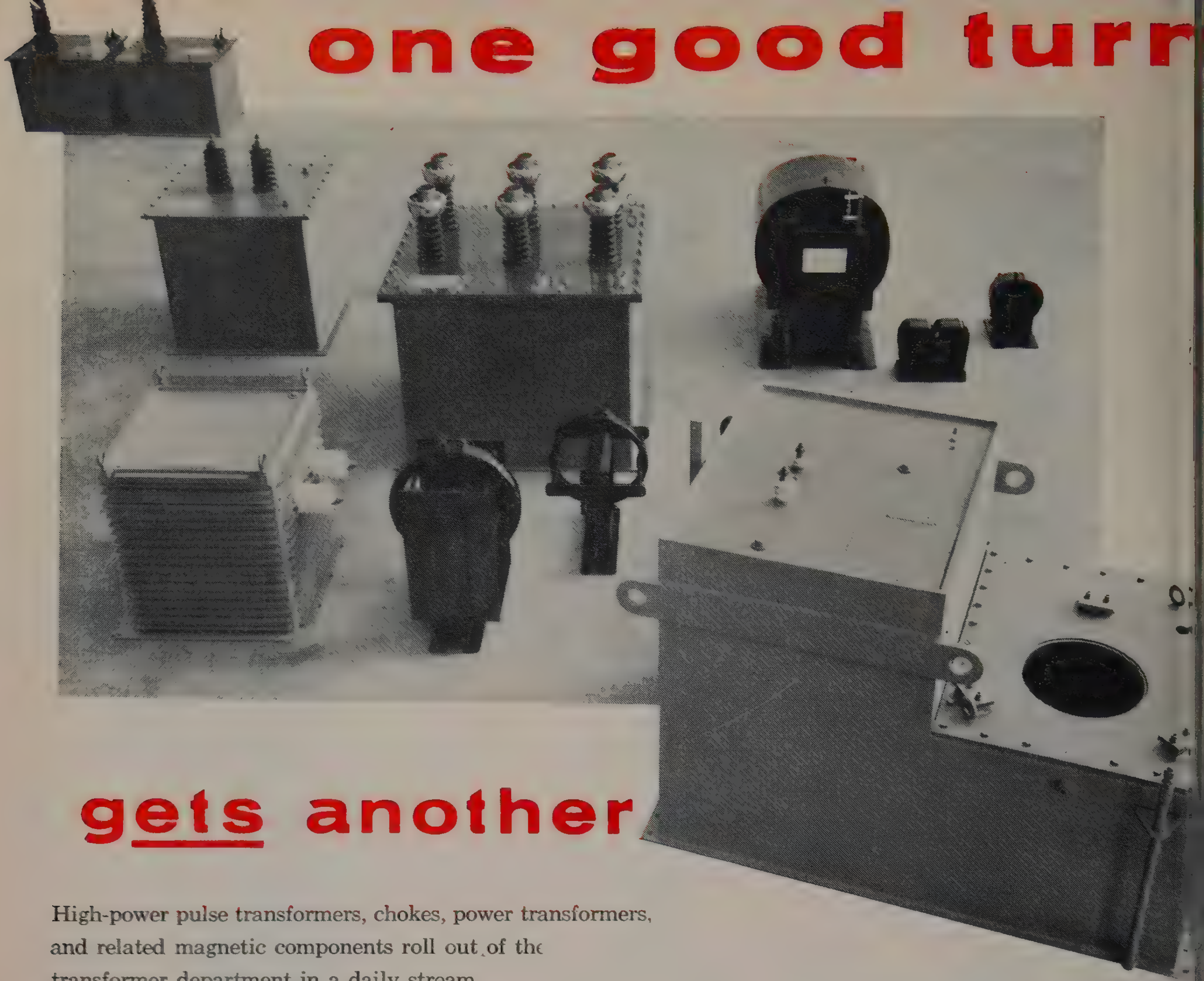
one good turn



gets another

High-power pulse transformers, chokes, power transformers, and related magnetic components roll out of the transformer department in a daily stream.

The advanced and expanding facility for producing these specialized high-quality devices is limited physically only by the present bake-out oven which is 4½ by 9 by 6 feet. As far as we can discover, there is *no* limitation on the engineering skills of the staff.

They are prepared to undertake projects in the following general categories: Pulse transformers to 600 kv with average powers of several-hundred kva, peak powers to 100 megawatts, and pulse lengths to 500 μsec; Power transformers separately or in assemblies to commercial or MIL specifications over the range 10 to 55 kv d-c and 1 to 400 kva; Filter reactors in commensurate ranges; and High-voltage low-capacitance and/or high-reactance dry-type isolation transformers from 10 to 55 kv and with outputs from 100 v-a to 6 kva.

PULSE-TRANSFORMER ASSEMBLY
Above, complex pulse package for beam-type tube, to MIL-T-27A specification. Comprises main pulse transformer, low-capacitance filament transformer, filament-current transformer, beam peak-current transformer, secondary capacitance divider, tube socket, and focus-coil mount. Ratings: 132 kv at 98 amp peak; 11 μsec at 191 pps; 3.25 μsec at 381 pps.

RECTIFIER PLATE TRANSFORMER
Center, suitable for use with various rectifiers, unit supplies 45-kv d-c, with reversible polarity, at 0.15 amp. Includes: 3-phase delta to wye rectifier transformer and 6 rectifier filament transformers.

COMPACT CHARGING REACTOR
Far left, concentrating three times the power capability of the commercial unit, behind it, into a 17-in. cube, this MIL-spec choke has Class H construction and finned case for 180 C operation. Ratings: 3.45 hy, 22.5 kv peak, 3.40 amp, 190 pps.

MISCELLANY
Other units shown include 40- and 50-kv low-capacitance filament or isolation transformers from a standard line and miscellaneous low-voltage filter chokes.

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TRANSMITTERS, MODULATORS, AND POWER SUPPLIES FOR COMMUNICATION, RADAR, AND TUBE DEVELOPM

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RADIATION

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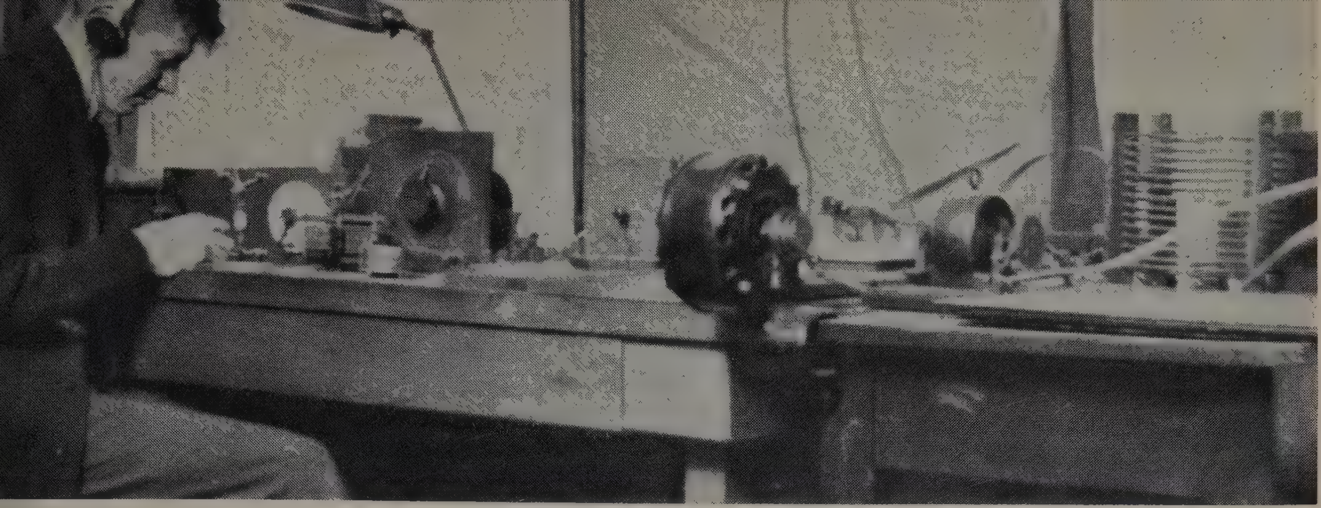

a 1916 photograph, Frederick Terman is shown in his ham shack. His transmitter was one-half a kilowatt with rotary spark gap. helix was used for tuning. His receiver had an audiotron tube on the panel and a storage battery and used a loose coupler for tuning.

ERMAN

(*Continued from page 14*)

ere considerate enough to hold open the jobs until my covery. I chose Stanford, feeling there was a tremendous ea of possible growth in their engineering department."

Dr. Terman's battle with tuberculosis at this time was uite prolonged. He had severe eye damage and at times uld only read for a few minutes at a time. He learned make every one of those minutes count, and the good udy habits he developed then have helped him throughut his busy career.

It was while he was teaching and developing his courses radio engineering that he met Sibyl Walcutt, a gradue student in psychology, his father's department. In ct, his father introduced them. After a few dates, Dr. erman looked up the file on Sibyl to check on her ptitude and I.Q. tests. He married her in 1928. And ortly afterwards, and old friend of hers from the Uniersity of Arizona helped persuade Dr. Terman to write Radio Engineering".

"I always felt there was great need of a text in radio ngineering and intended writing one sometime in the ture. But Sibyl's friend, a McGraw-Hill salesman amed Curtis Benjamin who had been visiting us on camus, told the publishers about my ideas and they peraded me to start the book right away. Today Benjamin President of McGraw-Hill.

"Actually, I started the book in the summer of '29 and was published in '32. Prior to that I had been a junior thor of sorts with William Franklin on 'Transmission ine Theory'. Franklin was an uncle of my old boyhood iend Jack Franklin, and he was a man who taught me great deal.

"Today 'Radio Engineering' is in its fourth revision, d if there has to be another, I shall need full-time colborators," Dr. Terman said, viewing any such underking on his own as impossible with the busy schedule e keeps as Vice President and Provost at Stanford Uniersity.

When I asked him in how many languages it had been ublished, Dr. Terman took me over to his bookshelves d took down editions of his various books in Japanese, orean, Chinese, Italian, Spanish and Polish to name a w. "The Poles actually paid me royalties," he commented. "The Japanese pirated an edition during the war for which I received nothing. But now they have made an authorized translation."

He showed me two Russian translations. The first one of "Radio Engineer's Handbook" was published in 1950 and gave full credit to a Russian author who's preface contains an ironic statement to the effect that the book was based on Frederick Terman's "Radio Engineer's Handbook". The second, a translation of "Electronic Measurements" was published in Russia in 1953 and gave Dr. Terman and Dr. Pettit credit as authors.

"In fact, I could presumably collect some rubles from this book if I want to go to Moscow to spend them," he added.

Dr. Terman had just returned to Stanford from serving a year as president of the Institute of Radio Engineers, when he was approached to become Director of the Harvard Radio Research Laboratory. "This was between Christmas and New Year's of 1941," Dr. Terman said. "I went back east to find that this was to be the chief U. S. agency for developing electronic countermeasures

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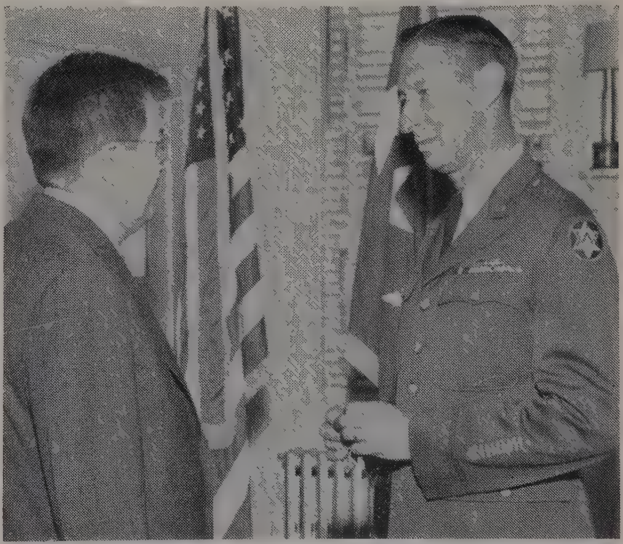
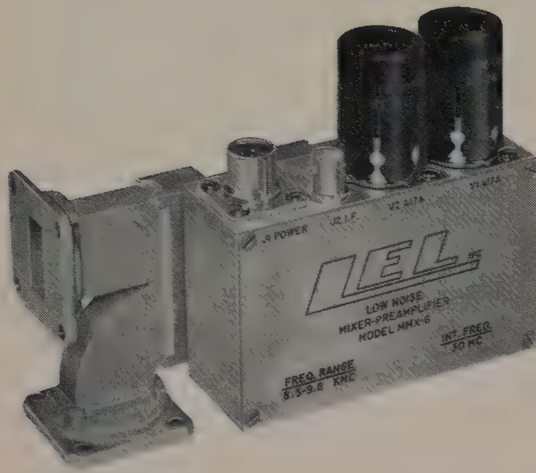


Dr. Frederick E. Terman is presented the "Badge of Military Merit," the nation's highest award for civilians, by General Mark Clark, Commanding General of the Sixth Army, in July, 1948. Dr. Terman was honored for his work with the Radio Research Laboratory at Cambridge, Massachusetts.

7.5db Noise Figure

in C or X BAND



MATCHED MIXER-PREAMPLIFIERS

(Coaxial units available for L, S and C bands)

TYPICAL SPECIFICATIONS

Noise Figure	6.5db typical 7.5db maximum
Bandwidth	8mc
Inputs	RG52/U Waveguide
Minimum Overall Power Gain	25db
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TERMAN

(*Continued from page 17*)

against enemy radar. It was so top secret, though, that I wa unable to tell people what I was hiring them to do.

"Besides this, by the time we got organized to hir people in the spring of '42, almost all the scientists an engineers had been snapped up by other agencies. Th forced us to look to young men just graduating fro the colleges. In fact, the majority of our technical peop were under 26 on the staff that eventually numbered 8 people. Many of the men came from Stanford, such a Mike Villard, Karl Spangenberg, Bill Rambo, and J Pettit, who succeeded me as Stanford's Dean of Eng neering.

"I found it the biggest challenge of my career up t that time, as prior to taking this position, my experien consisted of heading up a small department of six facult men and a part time secretary. This was quite a dramat change."

His voice warmed as he continued. "We had a 'fre hunting' license at the war laboratory. We did not hav to go through channels and the red tape of the arme forces. We were to find what the services needed i countermeasures and supply them with it. This resulte in our setting up our own intelligence system from a over the world. We had men stationed all the way fro the South Pacific to China and Kiska, in North Afric France, Sicily, England, on every front of the war excep Russia. We lost one man; he was strafed during th Battle of the Bulge.

"Our main job was to build jamming devices," D Terman remarked. "The British had already successfull jammed some of the German navigational radio when w came into the picture. We developed 'window' or alum num foil strips which were dropped from planes to jar enemy radar and radio." They also built new 'nois transmitters, high-frequency radio transmitters of unpre cedented power, search receivers for intercepting rad signals and determining their frequencies and location and many other devices. During the latter part of th war in Europe every heavy U. S. bomber carried abou two million strips of foil and two radio noise jammer They were very effective against the German radar-co trolled antiaircraft fire, and saved many bombers, pa ticularly when overcast prevented visual range finding.

At this point Dr. Terman showed me a map of th Pacific Ocean area and the Japanese radar installation spotted by this equipment.

"Actually, this equipment was useful against the Ger mans who had a highly developed radar system. In con trast, the Japanese radar was so poor and hence of s little value to the Japanese that making it useless didn' help our boys much," Dr. Terman observed.

"A lot of our equipment was used on D-Day in th Normandy invasion. I am not sure how much good it di there, however. Although the Germans had 500 rada installations along 200 miles of coastline, many wer already deactivated by the heavy bombings beforehand Still," Dr. Terman said, settling back on the couch with reminiscent smile, "one of our more exciting experience of the war came out of the activities prior to the landing

(*Continued on page 20*)

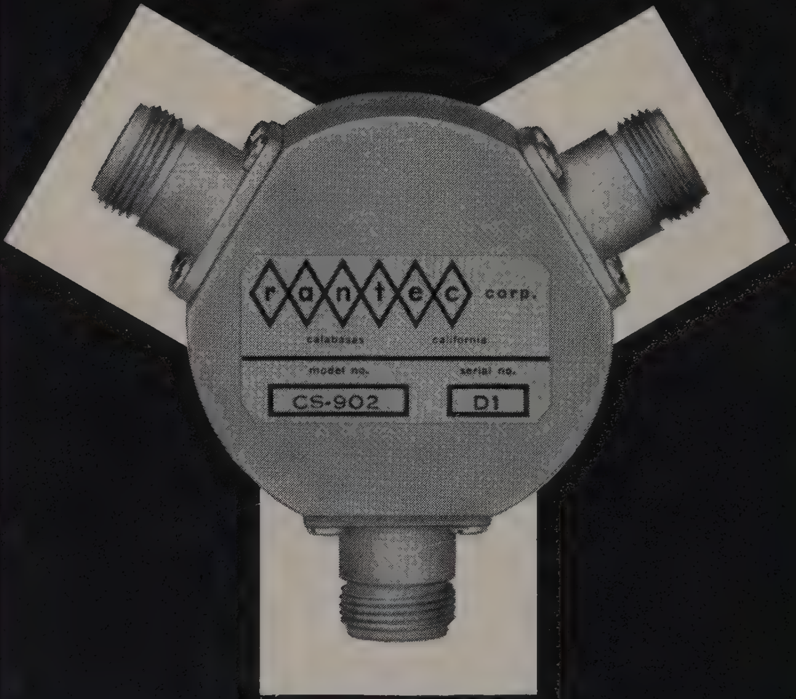
There are times, not many, in every man's life when he quails. And this holds true for the men strongest and stoutest of heart. Personally, we at Rantec never fire until we see the whites of their eyes, we damn the torpedoes and we have but one life to give for our country. This is all very well and good and we usually don't go about bragging about our unlimited bravery. Actually, what we are doing is rationalizing, since one thing, just one, turns our knees to jelly, our hearts to ice, our warm blood cold. Buy-off day.

The day normally begins gently warm, softly breezed and with the sun at its most friendly. The first call is from a satisfied customer who says he likes our microwave sub-system so much he is going to buy a gross. We thank him profusely and wish him and his lovely wife a good day. The second call is from the Air Force. The Buy-off man is coming: Hail begins to fall, soft breezes turn to gales and the sun vanishes forever. We have spent thirteen weeks (did it have to be that number?) designing and developing, producing and testing this particular inverse frequency modulator. It has been working perfectly now for a week under every conceivable type of environmental and physical torture. But do you think it will work today in the comfort and coziness of its own little living room. You guess. We're afraid to.

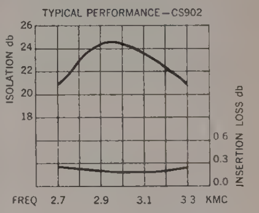
On this particular day, we ushered the Buy-off man into the laboratory. We were laughing nervously and we knew it, but who can face a situation such as this. There the modulator was sitting, effulgent in its simplicity, yet we knew it was conjuring up unthinkable evil. We turned on the current. The damn device played the Star Spangled Banner and then did Polka Dot Bikini as an encore. It surprised us only slightly. We were expecting Danse Macabre.

What we at Rantec need is comfort in these trying times. If you are an engineer with insuperable knowledge and experience in ferrite devices, microwave components and antennas, call us quick. DIamond 7-5446 or DIamond 7-5446 collect. You can have our job. We're going to be a Buy-off man.

Y-CIRCULATOR? For a wide variety of reasons... because, first of all, it is broad band... because it is compact and lightweight... because of its extremely high isolation and low insertion loss. These Y-Circulators were specifically designed for use in duplexing systems as well as with masers and parametric amplifiers. Because they are adaptable... by terminating one arm in a dummy load, this device can be used as a broad band isolator. With other modifications it can be utilized as a switch, variable attenuator or amplitude modulator. Finally (and certainly something on which you can rely), because it's from Rantec.



	CS-902 (illustrated)	CXB903	CS-900
Frequency Range	2.7-3.3KMC	5.4-6.7KMC	2.2-2.4KMC
Isolation	20db	20.0db	18db
Insertion Loss	0.4db	0.4db	0.4db
VSWR	1.3:1 Max.	1.3:1 Max.	1.3:1 Max.
Power Handling	5KW Peak 5 Watts Avg.	5KW Peak 5 Watts Avg.	5KW Peak 5 Watts Avg.



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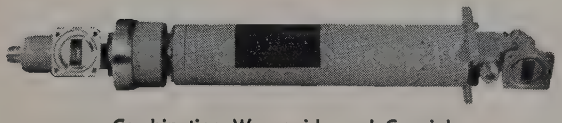

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DICO

TERMAN

(*Continued from page 18*)

"We had one perpetual problem with all the young men in our laboratory—the draft boards were constantly hot on our heels, and sometimes we were forced to put our young men in overseas positions to satisfy those boards. Just before the invasion, we received a telegram from Eisenhower asking for fourteen experts from our staff to report to England on Thursday. As the telegram arrived on Monday, it was an almost impossible situation. It generally took us at least three weeks to clear our men through their draft boards, alone, plus getting passports and shots.

"We informed the War Department of this and they said they'd handle it. Curious to find out how they were going to expedite matters, I listened in on one of the conversations from the War Office. I couldn't help being amused," Dr. Terman said, shaking his head at the memory. "The man calling the different agencies for clearance would say, 'You say it's impossible? Then would you please stop over at the War Department and explain why to General Marshall—why you are unable to carry out General Eisenhower's request.' There was never any further argument. By Wednesday night nine men were cleared and by Thursday night the remainder were ready. All the War Department asked us was not to request another job like this for at least a year."

It was during these days that Dr. Terman established invaluable contacts with various branches of the government in Washington, D.C., also with members of MIT and Harvard. "And it was while I was still with the Radio Research Laboratory that I realized there was going to be a new situation in research after the war. The government had used the universities for research programs, had found it not only a good working relationship, but profitable in the results that had been achieved. It seemed clear that this would continue after the war. I discussed it with my colleagues at MIT and Harvard to find out how they proposed to handle the situation at their schools and then combined their ideas with my own in a manner that was adapted to Stanford.

"Accordingly, when I returned to Stanford, I was ready with a plan of using graduate students and faculty in government supported research. I felt that in this way Stanford could get into the major leagues in engineering and science. By this time I had been appointed Dean of Engineering, and began preparing the groundwork for the expansion I knew would come."

And expansion did come, and then it received added impetus from the Korean War. Stanford, already in 1950 well on the way with government supported research at the instigation of Dr. Terman, reaped the benefits of this new growth. From an Electrical Engineering Department which had six staff members prior to World War II and a small reputation in electronics, Stanford University today has 400 students in its graduate program in electrical engineering and trains more PhD's in electronics than any other school in the country. The faculty also directs a $3.5 million per year research program in electronics, the results of which are open to industry. In turn, industry, cognizant of the opportunities here, has flocked to the San Francisco Peninsula.

(*Continued on page 22*)

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  - Lightweight units
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    TWT Production
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- TWT LIFE TEST SYSTEMS
  - Single tube units
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- TWT and KLYSTRON PULSERS
  - Millimicrosecond pulsers to
    Millisecond pulsers -
    to 50% duty cycle
- TWT SWEPT SYSTEMS
  - 10 Mw - 1 Watt CW
    10 Watt - 1 Kw peak
    Octave bandwidths
    ±1 db leveling from
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TERMAN

(*Continued from page 20*)

Recently, in a speech before the Sixteenth National Electronics Conference in Chicago, Dr, Terman said: "The new electronics lives close to the frontiers of science, and requires a high level of technical competence. It grows by the development of new products. It is characterized by the transistor and other solid state electronic devices, by electronic computers, by microwave technology in general and microwave tubes in particular, by automation, by the electronics associated with outer space research, etc."

In most of the areas named above, Dr. Terman as Provost of Stanford since 1955 is overseeing research work. There is the new Radioscience Laboratory under Mike Villard which is in the midst of constructing a million-dollar antenna, 15 stories high, for work in outer space research. There is a Solid State Electronics Laboratory which is studying semiconductors, ferrites, masers, parametric amplifiers, etc. Plasma Dynamics is under intense scrutiny by the scientists interested in the properties of gases, re-entry, fusion, etc.

In microwave research, Stanford has been a leader, beginning with the invention of the klystron at Stanford by Russell Varian and of the cavity resonator by Bill Hansen. Work in this field is continuing in traveling-wave tubes, backward wave oscillators and many areas of microwave technology.

During his speech at Chicago, Dr. Terman also chided midwestern industries and universities for their static "old" electronics. He said, "In the new electronics, education and also educational institutions, have a new and increasingly important role. Industry is discovering that for those types of electronic activities that involve a high level of creativity of a scientific and technological character, it is more important to be located near an educational institution than near markets, raw materials, component suppliers, transportation or factory labor." He went on to explain that the reason for this was that universities are the sources of the highly trained young men needed in creative electronics, are sources of ideas from their research activities which are often directly exploitable commercially, provide faculty members as a panel of experts and provide training for industry employees.

He continued to say that midwest electronics had been more interested in exploitation and refinement of existing ideas and product lines than in opening up new fields of activity. In the meantime, back at the "farm", the nickname for Stanford's campus, and on the east coast near schools such as MIT and Harvard, companies have prospered and demonstrated the possibilities of growth and profits through developing products in which a high proportion of the value was in the engineering involved, in contrast to the midwest where the value is more in material and labor costs.

Dr. Terman finished by saying, "It is surprising that there are not more electronic companies of the creative type clustered around such schools as the University of Illinois, Michigan, Wisconsin, Northwestern, Purdue, etc. This is the result of lack of vision on the part of industry and of lack of leadership on the part of the edu-

(*Continued on page 24*)

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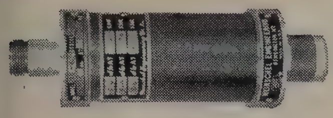
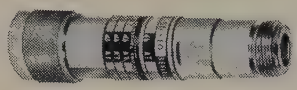
All attenuators and terminations made with Weinschel Film Resistors for maximum stability.
All attenuators and terminations individually calibrated.

- *Certificate of calibration supplied with each attenuator.*
- *All instruments 100% tested for all performance specifications.*



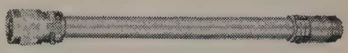
10 Watt Power Pads, Model 10

Frequency: DC to 2 KMC. 50 ohms. Attenuation: 1 to 20 DB. Maximum VSWR: 1.15, bilateral. Stainless steel type N connectors. Stable under power.



Coaxial Attenuators, Models 50, 50-C, 50-SC

Frequency: DC to 2 KMC. 50 ohms. Attenuation: 1 to 50 DB. Maximum VSWR: 1.15, bilateral. Finish: Stainless steel (Type N connectors); nickel plated (Type C or SC connectors).

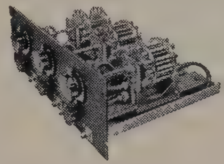


Coaxial Attenuators, 1 to 12.4 KMC—Models 210, 520, 540, 633, 663

Frequency: 1 to 12.4 KMC. 50 ohms. Attenuation: 1 to 20 DB. Finish: stainless steel (Type N Connectors); nickel plated (Type C, BNC, TNC, SC connectors). Available also in ruggedized version to meet MIL-A-3933 and MIL-T-945A (Model 530).

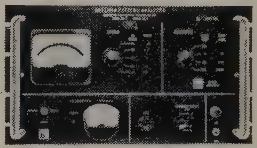
Coaxial Terminations—Model 535

DC to 10 KMC. Maximum VSWR with male or female Type N connectors: DC to 1 KMC: 1.03; 1 to 4 KMC: 1.05; 4 to 10 KMC: 1.15. Individual VSWR calibrations supplied at DC, .4, 1, 2, 4, 7.5 and 10 KMC. Connectors: N, C, SC, BNC, TNC.



Step Attenuators

DC to 1 KMC. RF calibration accuracy: 1 to 10 DB: .02/DB; 20 to 50 DB: .02 DB/10 DB. Model 60: 2 drums, 0-60 DB in 1 DB steps. Model 64: 3 drums, 0-64 DB in .1 DB steps. Model 640: 3 drums, 0-110 DB in 1 DB steps. Switch repeatability: .01 DB.



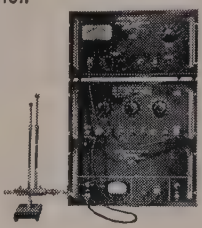
Antenna Pattern Analyzer, Model BA-7

Dynamic range 40 to 45 DB (R.F.) below maximum level of 1 microwatt using RF crystals. For description of the video detector system and associated instrumentation for pattern recording, write for Application Note #5.

Double Stub Tuners

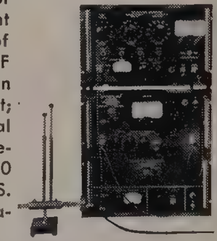
Adjustable spacing between stubs for quick matching. Chart on base for optimum stub spacing versus frequency. Collets lock stubs. Adjustable height of connectors. Frequency Ranges: Model DS 109: .75 to 10 KMC; Model DS 109L: .4 to 4 KMC; Model DS 109LL: .2 to 2 KMC.

Single Channel Insertion Loss Test Set
(Simple, Accurate)



Measure Attenuation directly up to 30 DB. Typical systems error: .1 DB. Resolution: about .02 DB. Frequency Range: 20 MCS to 90,000 MCS. Write for Application Note #1.

Dual Channel Insertion Loss Test Set
(High Resolution)

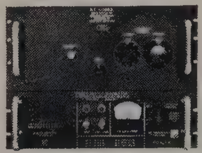


.02 DB precision for 20 DB measurement despite changes of .1 DB in level of RF source. Attenuation range: 20 DB, direct; 40 DB with partial RF substitution. Frequency range: 20 MCS to 90,000 MCS. Write for Application Note #4.

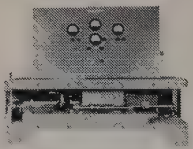
Precision RF Power Bridge, Model PB-1

For standards laboratories requiring the highest possible accuracy in high frequency power measurements . . . capable of accuracies of .1% in the measurement of substituted DC power.

Modulated RF Sources—Models MS-8 to MS-13



Exceptional amplitude and frequency stability for precision microwave measurements. Six RF Sources plug into common Power Supply-Modulator, cover frequency range of 50 to 10,500 MCS with true single-knob control. Modulator frequency is tuning fork stabilized.



Standard Attenuator Comparator, Model VM-1B
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For standards laboratories. Calibrates signal generator output attenuators or calibrates attenuators. 105 DB range. Accuracy between —21 and—81 DBM is .02 DB/10 DB.

Write for complete specifications.

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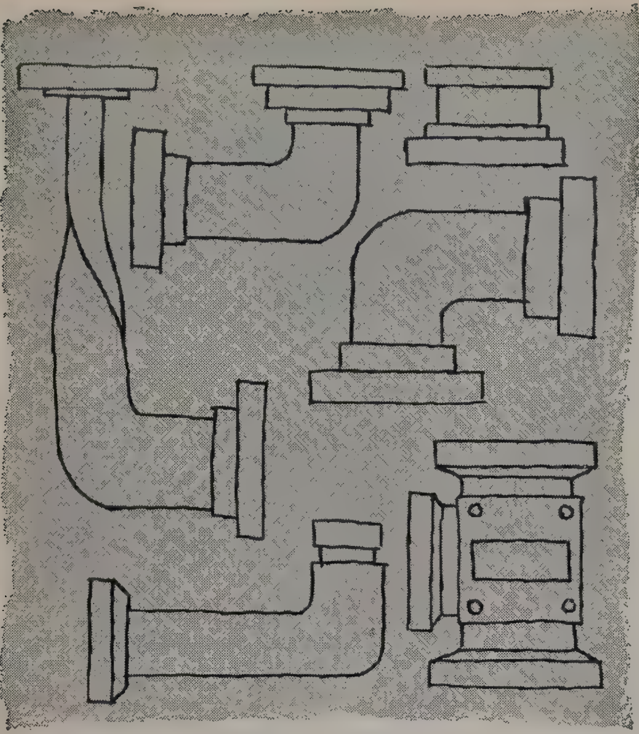

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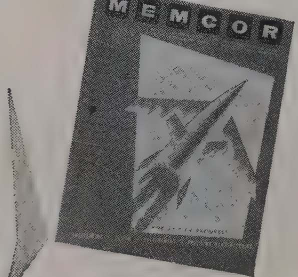

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TERMAN

(*Continued from page 22*)

cational institutions. On this particular point, the principal blame may well be placed on the doorsteps of th universities involved; they have had it in their powe to take much more initiative than they have taken, an it is in their self interest to do so."

When asked if he hadn't been somewhat harsh in h criticism, Dr. Terman chuckled. "I believe they asked m to speak, wanting me to say what I did," he replie "They needed some shock therapy."

Dr. Terman is surrounded by a family as energetic an dynamic as himself. His three sons have all become sc entists. "Fred is now an assistant professor at Adelph and has his undergraduate degree in electrical enginee ing and his graduate work in physics. Terence is teachin at Los Angeles State and did his graduate and undergrad ate work in physics. Lewis, the youngest, received h bachelor's degree in physics and switched to EE. He work for IBM."

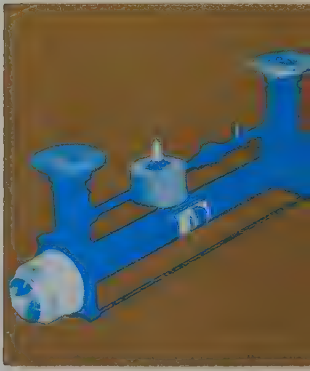
Dr. Terman's wife Sibyl, a remedial reading exper has become a celebrity in her own right in authoring book with her brother Charles Walcutt called "Reading Chaos and Cure." The book which calls on schools t employ phonic-based reading methods instead of usin the "look-say" method has caused considerable contro versy in fields of education. This, in turn, has brough volumes of mail to their house.

If Dr. Terman was not busy enough already, he serve as acting president of Stanford for the last three month of 1960 while Dr. Sterling was overseas. As he remarke "I never realized before how much a president had to d to earn his pay."

I asked Dr. Terman which was the most importan feature he looked for in hiring new people for the facu ty. He said, "We look for different things, depending o the job. If it's strictly a teaching post, we look for apt tudes there. If we want a man more for research, w consider those qualities foremost. But one of the mo important things to do in selecting faculty members is t wait for the better man to be available. Don't settle f second best even if you have to wait two or three year to get your man."

When asked what accomplishment gave him the mo satisfaction, Dr. Terman pondered for a few momen before answering. Then he said, "This isn't an exac answer to your question, but I most enjoy helping t build something up, taking an unformulated enterpris and making it into what it could become." His eng neering books, his work at the Radio Research Labora tory, his work at Stanford University all attest to hi interest and abilities in this line.

But Frederick Emmons Terman is not only a builde a teacher, an engineer; he is a visionary seeing a challeng in the new electronics which he still views with a sense o wonder and excitement. Certainly the electronic age ha come a long way since he operated his 200 meter spar rig with Herbert Hoover Jr., and so has Dr. Terman, man who always looks at the present with an eye to th future. Like John Paul Jones who said, on looking at th battle about him, "I have not yet begun to fight," D Terman's credo might well be, on looking at the elec tronics field, "We have not yet begun to know."



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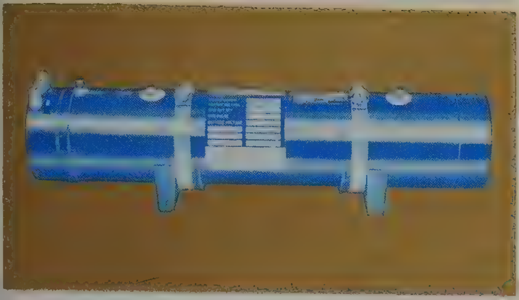
All specifications are current as of December 1, 1960. Please contact the Hughes Microwave Tube Division for specification changes which might occur, or for modifications to specifications which may better suit your system requirements.



311H

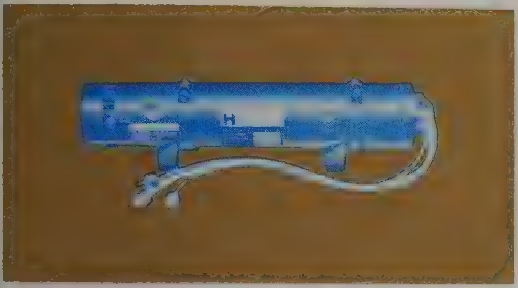
The 311H is a gridded, permanent-magnet, periodically focused S-Band TWT, particularly useful for microwave applications which demand 1 kw of pulsed output power, up to 1% duty, low r-f driving power, light weight, compactness, and reliability. It contains an internal blower and has a gas filled package. The tube can be used at both low and medium power positions in a chain of r-f amplifiers.

TYPICAL OPERATION

Frequency	2.0-4.0 kMc	Cathode Current	1.3 a
Minimum Power Output, Peak	1 kw	Grid Voltage	
Minimum Power Output, Average	10 W	Peak (above cathode)	250 v
Gain (at 1 W input)	30 db min.	Bias	—90 V
Gain (at 50 mW input)	36 db min.	Heater Voltage	6.3 V
Beam Voltage	7 kV	Heater Current	3.0 A
		Grid Capacitance	15 μμf

CHARACTERISTICS

Focusing	PPM
External Cooling	75 CFM Air
Internal Cooling	110 V, 400 cps, single-phase blower
Dimensions	17 7/16″ long x 3¾″ O.D.
Weight	12.5 lbs.
R-F Connectors	TNC
Environmental	MIL-E-5400, Class I



312H

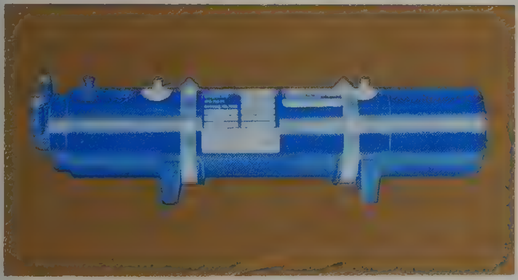
The Hughes 312H is similar to the 311H in that it also is a gridded, permanent magnet, periodically focused, S-Band TWT with 1 kw of pulsed output power. It operates at 0.5% duty. It has the same outstanding operating characteristics as the 311H. It requires less cooling air and is lighter in weight.

TYPICAL OPERATION

Frequency	2.0-4.0 kMc	Cathode Current	1.3 a
Minimum Power Output, Peak	1 kw	Grid Voltage	
Minimum Power Output, Average	5 W	Peak (above cathode)	250 v
		Bias	—90 V
Gain (at 1 W input)	30 db min.	Heater Voltage	6.3 V
Gain (at 50 mW input)	36 db min.	Heater Current	3.0 A
Beam Voltage	7 kV	Grid Capacitance	15 μμf

CHARACTERISTICS

Focusing	PPM
Cooling	50 CFM Air
Dimensions	15⅜″ long x 3″ O.D.
Weight	11 lbs.
R-F Connectors	TNC
Environmental	MIL-E-5400, Class I



304H

The 304H is a nongridded, cathode pulsed version of the 311H. It produces 1 kw of pulsed output power at duties up to 1%.

TYPICAL OPERATION

Frequency	2.0-4.0 kMc	Beam Voltage	7 kv
Minimum Power Output, Peak	1 kw	Cathode Current	1.25 a
Minimum Power Output, Average	10 W	Heater Voltage	6.3 V
Gain (at 1 W input)	31 db	Heater Current	3.0 A
Gain (at 1 mW input)	37 db	Cathode Capacitance	15 μμf

CHARACTERISTICS

Focusing	PPM
External Cooling	50 CFM Air
Internal Cooling	115 V, 400 cps, single-phase blower
Dimensions	17½″ long x 3¾″ O.D.
Weight	12.5 lbs.
R-F Connectors	TNC
Environmental	MIL-E-5400, Class I

313H

The Hughes 313H is a nongridded, cathode pulsed version of the 312H packaged in a different external configuration. It operates at 0.5% duty and features a very low cooling requirement.

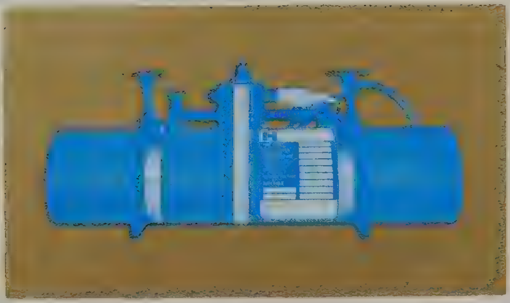
TYPICAL OPERATION

Frequency	2.0-4.0 kMc	Beam Voltage	7 kv
Minimum Power Output, Peak*	1 kw	Cathode Current	1.3 a
Minimum Power Output, Average	5.5 W	Heater Voltage	6.3 V
Gain (at 1 W input)	30 db	Heater Current	4.0 A
Gain (at 1 mW input)	36 db	Cathode Capacitance	15 μμf

*Over the center portion of the band.

CHARACTERISTICS

Focusing	PPM
Cooling	2 CFM Air
Dimensions	16⅝″ x 5″ x 3¾″
Weight	17.5 lbs.
R-F Connectors	UG19B/U
Environmental	MIL-E-1



310H

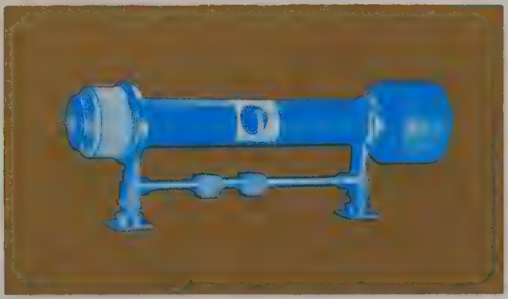
The 310H is a gridded, X-Band, metal and ceramic TWT, suitable for microwave applications that require 1 kw of pulsed output power at 2% duty, low input power, ruggedness, and reliability.

TYPICAL OPERATION

Frequency	8.5-10.5 kMc	Grid Voltage	
Power Output, Peak	1 kw	Peak (above cathode)	200 v
Power Output, Average	20 W	Bias	—150 V
Saturation Gain	40 db	Heater Voltage	6.5 V
Beam Voltage	10 kV	Heater Current	3.0 A
Beam Current	1.25 a	Grid Capacitance	25 μμf
Efficiency	10%	Insertion Loss (Beam cut off by grid)	>50 db

CHARACTERISTICS

Focusing	PPM
Cooling	120-275 CFM Air
Dimensions	16" long x 3⅞" O.D.
Weight	15 lbs.
R-F Connectors	Flange to RG-52/U Waveguide



308H

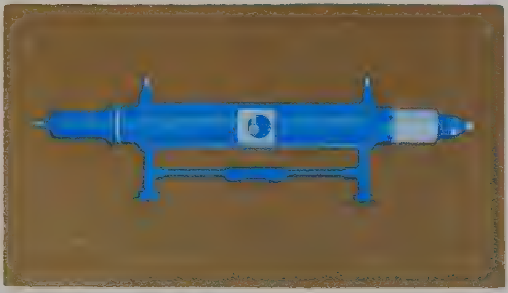
The 308H is a gridded, X-Band, metal and ceramic, high-μ TWT for use in systems which require minimum phase variations during the pulse, fast rise time, and minimum amplification delay time. A broader band (8-10 kMc), temperature compensated version is now being developed.

TYPICAL OPERATION

Frequency	8.6-9.8 kMc	Grid Voltage	
Power Output, Peak	15 kw	Peak (above cathode)	180 v
Power Output, Average	150 W	Bias	—300 V
Saturation Gain	53 db	Heater Voltage	12 V
Beam Voltage	24 kV	Heater Current	3.5 A
Beam Current	5.5 a	Grid Capacitance	20 μμf
Efficiency	12%	Insertion Loss (Beam cut off by grid)	>300 db

CHARACTERISTICS

Focusing	PPM
Cooling	
Gun	10 CFM Air
Collector	50 CFM Air
Dimensions	19" long x 3½" O.D.
Weight	14 lbs.
R-F Connectors	UG-39/U (RG-52/U Waveguide)



307H

The 307H is a light weight, X-Band, metal and ceramic TWT which is ideal as a driver for crossed-field output amplifiers or as an efficient single tube transmitter. Freedom from microphonics and phase shift variations satisfies the most stringent system requirements for "chirping," MTI, and multi-element phased arrays.

TYPICAL OPERATION

Frequency	8.5-9.5 kMc	Beam Current, Peak	11.2 a
Minimum Power Output, Peak*	50 kw	Efficiency	20%
Minimum Power Output, Average	500 W	Heater Voltage	15 V
Maximum Duty	.01	Heater Current	5 A
Saturation Gain	54 db	Cathode Capacitance	20 μμf
Beam Voltage	37-40 kv	Insertion Loss (Beam off)	>300 db

*At a slightly increased beam voltage, 100 kw power output can be achieved over part of the band.

CHARACTERISTICS

Focusing (Temperature Compensated)	PPM
Cooling	0.75 gpm Water
Dimensions	24" long x 3" O.D.
Weight	21 lbs.
R-F Connectors	UG-39/U (RG-52/U Waveguide)

326H

The 326H backward-wave oscillator has been especially designed for use in test equipment and other commercial instrumentation. Like all Hughes BWOs, the 326H requires no external cooling. All electrodes are isolated from each other and from the case. It is a small, streamlined tube with excellent operating characteristics; long life and ruggedness are inherent in its design.

TYPICAL OPERATION

Frequency	12.4-18.0 kMc	Anode 1 Voltage	150 V
Power Output		Helix Voltage	534-1853 V
Minimum	10 mW	Cathode Current	6 mA
Midband	65 mW	Grid Characteristics	
Duty	CW or Pulse	C-W Operation	0 V
Spectrum Width	50 kc	R-F Cut Off	—20 V
Heater Voltage	6.3 V	Beam Cut Off	—100 V
Heater Current	.84 A		

CHARACTERISTICS

Focusing	PM
Cooling	Ambient Air
Dimensions (Excluding mounting feet)	7¾" x 4" x 4"
Weight	10.5 lbs.
R-F Connectors	UG-541/U (RG-91/U Waveguide)
Environmental	
Vibration	10 g max. .06" D.A. to 55 cps
Shock	20 g for 11 msec.

315H

The 315H is a voltage tunable K_U-Band backward-wave oscillator developing a minimum of 50 milliwatts over the frequency range 15.8-17.2 kMc. It is an ideal signal source for microwave signal generators, panoramic receivers and spectrum analyzers, frequency scan and navigation radars, microwave relay links and countermeasures equipment. It has the same tuning curve as the 326H. It has an extremely rugged package suitable for any military environment.

TYPICAL OPERATION

Frequency	15.8-17.2 kMc	Heater Current	.84 A
Power Output	50 mW	Anode 1 Voltage	150 V
Duty	CW or Pulse	Helix Voltage	1162-1590 V
Spectrum Width	50 kc	Cathode Current	6 mA
Heater Voltage	6.3 V		

CHARACTERISTICS

Focusing	PM
Cooling	Ambient Air
Dimensions	9 5/16" long x 3.53" O.D.
Weight	12 lbs.
R-F Connectors	UG-541/U (RG-91/U Waveguide)
Environmental	
Vibration	10 g max. .06" D.A. to 55 cps
Shock	20 g for 11 msec.

316H

The 316H is a voltage tunable K_U-Band backward-wave oscillator developing a minimum of 10 milliwatts over the frequency range 12.4-18.0 kMc. It is similar to the 326H but contains an extremely rugged package suitable for any military application.

TYPICAL OPERATION

Frequency	12.4-18.0 kMc	Heater Current	.84 A
Power Output — Midband	65 mW	Anode 1 Voltage	150 V
Duty	CW or Pulse	Helix Voltage	534-1853 V
Spectrum Width	50 kc	Cathode Current	6 mA
Heater Voltage	6.3 V		

CHARACTERISTICS

Focusing	PM
Cooling	Ambient Air
Dimensions	9 31/32" long x 5 5/16" O.D.
Weight	12.5 lbs.
R-F Connectors	UG-541/U (RG-91/U Waveguide)
Environmental	
Vibration	10 g max. .06" D.A. to 55 cps
Shock	20 g for 11 msec.

317H

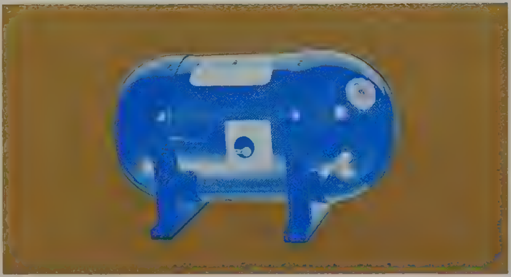
The 317H is a voltage tunable K_U-Band backward-wave oscillator developing a minimum of 10 milliwatts over the frequency range 10.7-16.2 kMc. It has essentially the same voltage range as the 316H.

TYPICAL OPERATION

Frequency	10.7-16.2 kMc	Heater Current	.84 A
Power Output — Midband	65 mW	Anode 1 Voltage	150 V
Duty	CW or Pulse	Helix Voltage	545-2000 V
Spectrum Width	50 kc	Cathode Current	6 mA
Heater Voltage	6.3 V		

CHARACTERISTICS

Focusing	PM
Cooling	Ambient Air
Dimensions (Excluding mounting feet)	9 31/32" long x 5 5/16" O.D.
Weight	12.5 lbs.
R-F Connectors	UG-541/U (RG-91/U Waveguide)
Environmental	
Vibration	10 g max. .06" D.A. to 55 cps
Shock	20 g for 11 msec.



318H

The 318H is a voltage tunable K_U-Band backward-wave oscillator developing a minimum of 10 milliwatts over the frequency range 15.0-21.4 kMc. It has essentially the same voltage range as the 316H.

TYPICAL OPERATION

Frequency	15.0-21.4 kMc	Heater Current	.84 A
Power Output — Midband	30 mW	Anode 1 Voltage	150 V
Duty	CW or Pulse	Helix Voltage	664-2227 V
Spectrum Width	50 kc	Cathode Current	6 mA
Heater Voltage	6.3 V		

CHARACTERISTICS

Focusing	PM
Cooling	Ambient Air
Dimensions (Excluding mounting feet)	9 31/32" long x 5 5/16" O.D.
Weight	12.5 lbs.
R-F Connectors	UG-541/U (RG-91/U Waveguide)
Environmental	
Vibration	10 g max. .06" D.A. to 55 cps
Shock	20 g for 11 msec.

323H

The 323H is a low-noise backward-wave amplifier having a narrow pass band electronically tunable over an octave at S-Band, thus providing good selectivity and image rejection. An extremely low noise figure gives improved sensitivity and extended radar range. Cold isolation and power saturation characteristics provide excellent crystal protection and increased system reliability.

TYPICAL OPERATION

Frequency	2.0-4.0 kMc	Input-Output Isolation	>50 db
Power Output	1 mW	Maximum Voltage	2750 V
Duty	CW	Tuning Voltage	180-1150 V
Gain	20 db	Cathode Current	.7 mA
Midband Noise Figure	5 db	Heater Power	6.5 W
Midband Bandwidth	8 Mc	Magnetic Field	750 gauss
Midband Tuning Sensitivity	2.2 Mc/V		

CHARACTERISTICS

Focusing	Solenoid
Cooling	Forced Air
Dimensions with Solenoid (Excluding blower)	22 1/4" x 4 1/4" x 4 1/4"
Weight with Solenoid	50 lbs
R-F Connectors	TNC

(Solenoids are available at extra cost.)

324H

The 324H is a low-noise, X-Band backward-wave amplifier having a narrow pass band electronically tunable over the frequency range 8.5-9.6 kMc. The tube is housed in an air cooled, light weight, compact solenoid.

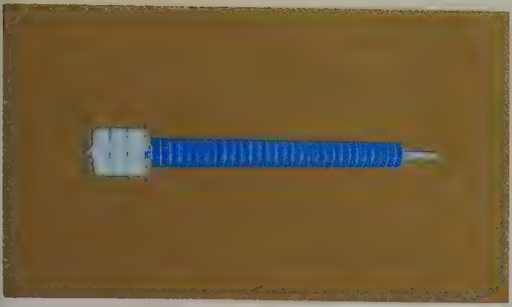
TYPICAL OPERATION

Frequency	8.5-9.6 kMc	Input-Output Isolation	>40 db
Power Output	.1 mW	Maximum Voltage	1500 V
Duty	CW	Tuning Voltage	423-625 V
Gain	20 db	Cathode Current	400 μA
Midband Noise Figure	5.5 db	Heater Power	3.6 W
Midband Bandwidth	12 Mc	Magnetic Field	1000 gauss
Midband Tuning Sensitivity	5.5 Mc/V		

CHARACTERISTICS

Focusing	Solenoid
Cooling	Forced Air
Dimensions with Solenoid (Excluding waveguide)	15 7/8" long x 3 7/16" O.D.
Weight	18 lbs.
R-F Connectors	UG-39/U (RG-52/U Waveguide)

(Solenoids are available at extra cost.)



314H

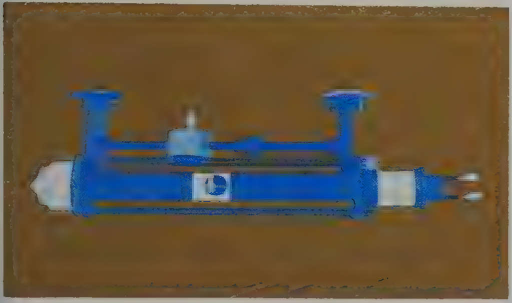
The 314H is an L-Band, light weight TWT suitable for satellite and other applications which require cw power at good efficiency. This tube has the fundamental attributes of long life, reliability, and the capability of operation in rugged environmental conditions.

TYPICAL OPERATION

Frequency	1.9 to 2.1 kMc	Anode Voltage	720 V
Power Output	2.5 W	Helix Voltage	580 V
Duty	CW	Collector Voltage	290 V
Saturation Gain	30 db	Heater Voltage	4 V
Efficiency (including heater power)	25%	Heater Current	0.5 A

CHARACTERISTICS

Focusing	PPM
Cooling	Forced Air, or by conduction to heat sink
Dimensions	7¾″ long x 1¼″ O.D.
Weight	0.4 lb.
R-F Connectors	Coaxial



306H

The 306H is a gridded C-Band metal and ceramic TWT. This tube provides very high gain and 20 kilowatts of power at 2% duty for pulsed transmitters. It is suitable for use either as a driver or as the final output amplifer.

TYPICAL OPERATION

Frequency	5.4-5.9 kMc
Power Output, Peak	20 kw
Power Output, Average	400 W
Saturation Gain	43 db
Beam Voltage	26 kV
Beam Current	6.5 a

Grid Voltage	
Peak (above cathode)	180 v
Bias	—500 V
Heater Voltage	11 V
Heater Current	5.9 A
Grid Capacitance	24 $\mu\mu$f
Insertion Loss (beam cut off by grid)	>300 db

CHARACTERISTICS

Focusing	PPM
Cooling	1 gpm Water
Dimensions (Excluding waveguide)	25½″ long x 3½″ O.D.
R-F Connectors	Flange to RG-50/U Waveguide

319H

The 319H is an X-Band, high gain, metal and ceramic TWT. This tube will supply 20 kilowatts of power at 1% duty for pulsed transmitters, and it can be used either as a driver or as the final output amplifier.

TYPICAL OPERATION

Frequency	8.4-9.5 kMc	Beam Current	6.5 a
Power Output, Peak	20 kw	Efficiency	16%
Power Output, Average	200 W	Heater Voltage	12 V
Power Input	100 mW	Heater Current	3.5 A
Saturation Gain	54 db	Cathode Capacitance	10 $\mu\mu$f
Beam Voltage	25 kv	Insertion Loss (beam off)	>300 db

CHARACTERISTICS

Focusing	PPM
Cooling	0.5 gpm Water
Dimensions	19″ long x 3½″ O.D.
Weight	17 lbs.
R-F Connectors	UG-39/U (RG-52/U Waveguide)

321H

The 321H is a metal-ceramic S-band amplifier TWT suitable for use as an r-f driver or output tube. Either the 304H or the 312H can provide adequate rf input to this tube.

OBJECTIVE OPERATING CONDITIONS

Frequency	2.85-3.15 kMc	Beam Current	28 a
Power Output, Peak	250 kw	Efficiency	15%
Power Output, Average	1.5 kW	Heater Voltage	11 V
Saturation Gain	26 db	Heater Power	150 W
Beam Voltage	55 kv	Insertion Loss (beam off)	>300 db

CHARACTERISTICS

Focusing	PPM
Cooling	Liquid
Dimensions (approx.)	36″ long x 5″ O.D.
Weight	100 lbs.
R-F Connectors	
Input	Type N Coaxial
Output	Flange to RG-48/U Waveguide

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	Frequency Range — KMC	A-Band 26.5–40	V-Band 50–75	E-Band 60–90	F-Band 90–140	Remarks
ORN ANTENNAS	Gain Standard Horns	A890	V890	E890	F890	Gain — 25 ± .3 db
	Linearly Polarized Feed	A895	V895	E895	F895	VSWR 1.2
	Circularly Polarized Feed	A900	V900	E900	F900*	Axial Ratio: .5 db for 6% band

Model No.	Diameter (inches)	Focal Length (inches)
903	3	3
906	6	6
909	9	9
912	12	12

Typical Performance at 4mm:

	Frequency Range — KMC	A-Band 26.5–40	V-Band 50–75	E-Band 60–90	F-Band 90–140	Focal Length (inches)	Gain (db above Isotropic)	3 db Beam Width	Max. Side Lobe (db)
COMPLETE PARABOLIC ANTENNAS	3 Inch Diameter		V803	E803	F803	1	32.9	3.80°	20
	6 Inch Diameter	A806	V806	E806	F806	2	38.9	1.90°	20
	12 Inch Diameter	A812	V812	E812		4	44.9	0.94°	20
	24 Inch Diameter	A824	V824	E824		8	50.9	0.47°	20
	36 Inch Diameter	A836	V836	E836		12	54.5	0.32°	20

*Under Development

TRG INC., ANTENNA & MICROWAVE DEPT., 9 UNION SQUARE, SOMERVILLE, MASS. PHONE: MOnument 6-8680

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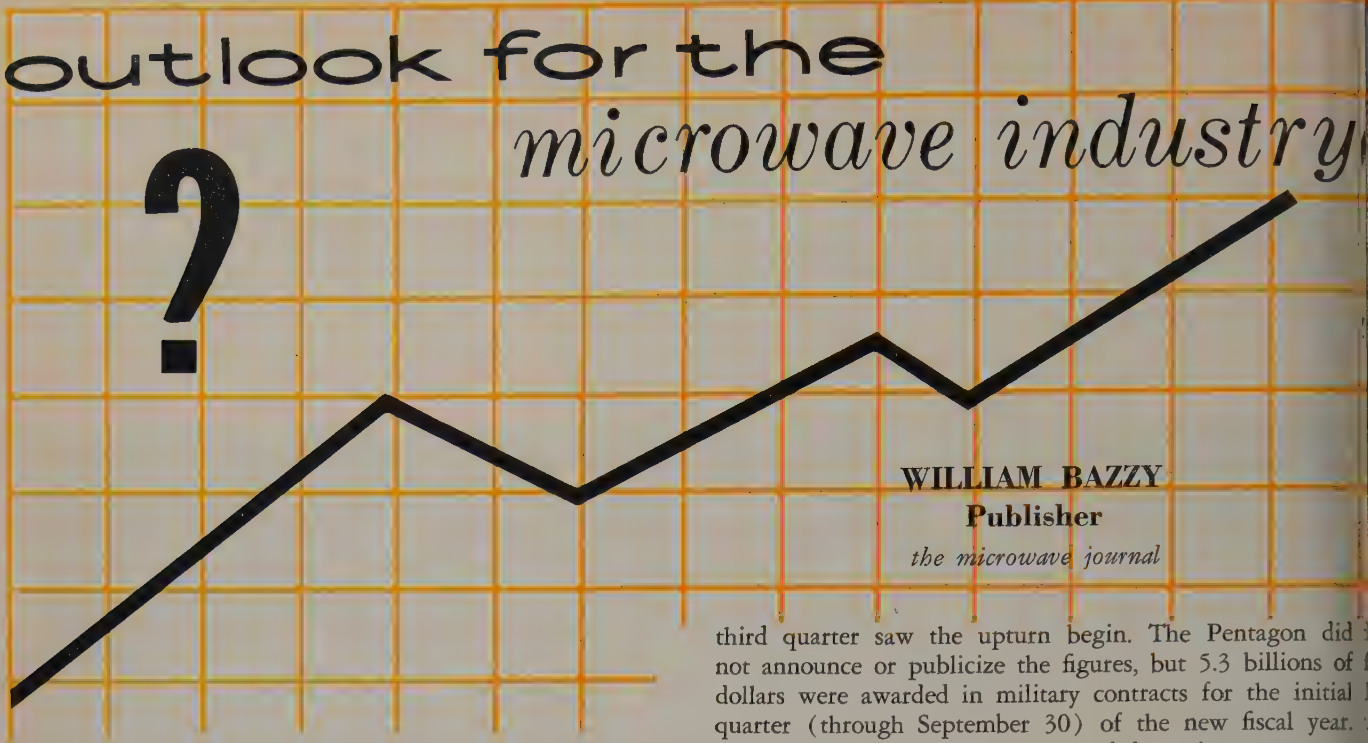
outlook for the microwave industry



WILLIAM BAZZY
Publisher
the microwave journal

The decade of the sixties was projected to be fabulous, soaring, roaring, etc. Upon close examination, this first year, 1960, did not live up to its projections. The anticipations by the microwave business community of the growth curve, continuing at the same rate as it had for the previous five years, were strong. Hopes and marketing surveys were set on high targets. A market analysis by one research firm held out great promise for long-term growth. Their report called the sixties the "Decade of Microwaves." Then the financial groups entered the scene in grand style, and capital flow was generated. Mergers and acquisitions were commonplace! Financial surveys covered the field, but facts were often garbled, leaving the industry activities poorly understood. Microwaves are a technique which financial people find difficult to understand.

There are, in our opinion, three distinct areas needing attention. (1) More knowledge and information to keep capital sources informed and investment money flowing. (2) Market information as to the current dollar volume expended in the various areas of interest to microwave manufacturers. (3) Information, development and research in new fields, new products, new systems and areas of growth.

A generalization can be made about the business volume experienced this past year in the various areas of the microwave industry. Random samplings in our journeys around the country showed, in general, that the average company did not fully realize its goals for annual gross sales in 1960. Many companies in 1959 anticipated fifteen to twenty per cent *increases* in total dollar volume as well as in profit margins for 1960. While these goals generally were not realized, however, the average firm did improve its '59 sales volume. The majority of firms interviewed reported a growth of eight to ten per cent over the previous year.

Returning to the first and second quarters of this past year (1960), we find that the "average" firm experienced a downturn in orders received. The low point was reached in the summer months of June, July and August. The third quarter saw the upturn begin. The Pentagon did not announce or publicize the figures, but 5.3 billions of dollars were awarded in military contracts for the initial quarter (through September 30) of the new fiscal year. This reflected a sizeable increase of forty-six per cent as compared to the same period in 1959. Conversely, the last quarter of fiscal '60 (April, May and June) was down five per cent over the same period the previous year.

Military buying continued to show gains. Two-thirds of a group of firms surveyed indicated a rise in business in October, November and December, 1960 over the corresponding period in '59.

Predictions are being made that the Pentagon will increase overall defense spending by twelve to fifteen per cent during this current fiscal year. This is in view of a drop in spending that ran eleven per cent the previous fiscal year. The previous five years showed uninterrupted increases.

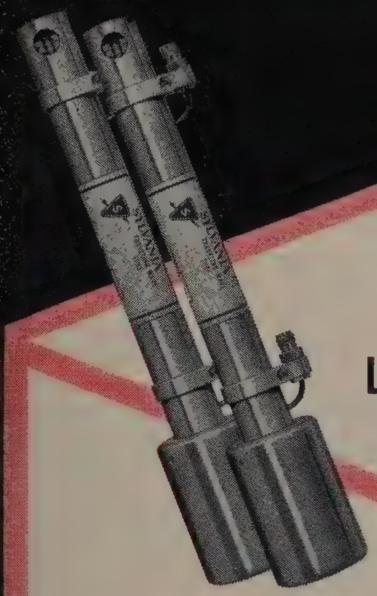
Efforts by the previous administration for a balanced budget reduced defense spending. Now, as the new administration takes over, the great guessing game is renewed. However, in view of the world political situation and the enormous power struggle, the guesswork is minimized.

A rise in defense spending is significant at this time. Many industries are experiencing a decline in business. The full impact won't be felt for many months, because of the normal lag between the awarding of contracts and the sub-contractors' translation of the awards into production. Despite the current rise in defense spending, payments are expected to decrease slightly in the year ending June 1961. The military continues to send out requests for bids, which indicates that defense production will be high.

Recent publicity given to the interest exhibited by several companies in the satellite "Project Echo" has aroused much speculation. The government agencies appear to have encouraged private and commercial interests to develop this communication potential. This action has hastened the possibilities of linking the nations of the earth by reliable and improved means of contact. Speculation is that the investment can be repaid in a fairly rapid manner with respectable profit margins annually.

(*Continued on page 36*)

MICROWAVE DEVICE NEWS from SYLVANIA



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for test equipment applications

TYPES	FREQUENCY RANGE (kMc)	POWER OUTPUT	GAIN-db (Min.)
TW-4267	1-2	10 mW	35**
TW-4268	1-2	1 W	30*
TW-4261	2-4	10 mW	35**
TW-4260	2-4	1 W	30*
TW-4281	4-8	10 mW	35**
TW-4278	4-8	1 W	30*
TW-4282	8-12	5 mW	35**
TW-4273	8-12	1 W	30*

**Small signal gain *At saturation

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GENERAL SYSTEM

BAZZY

(*Continued from page 34*)

A satellite reflector program would augment the potential for substantial market increases in the microwave industry.

A significant area of interest to the microwave field is in the point-to-point communications market. The questions most often posed, the surveys most frequently conducted, center around this activity. The current struggle before the FCC, to remove restrictions on allocations of frequency bands to commercial interests, is receiving strong attention. Profit potential for the microwave industry, afforded by removal of these restrictions has whetted many appetites. We have seen several companies, anticipating this action, expand their facilities and augment their engineering and marketing staffs. The Wall Street Journal, New York Times, New York Herald Tribune, Los Angeles Times, and Boston Globe have paid a great deal of attention to this segment of microwave business. The general conclusion appears to favor a rapid growth.

A crystal ball would be useful to forecast the future for microwave relay sales and the dollar volumes these systems could represent during this decade. Utilization of these channels, for commercial applications with voice channels, data transmission and telemetered functions for remotely operated units, has apparent economic advantages.

Sales volume for 1960 microwave relay sales is reported to be between ninety to one hundred million dollars. This relates to commercial sales and not to military units. An excellent future for these communication systems can be assumed.

The increase in data processing and computer equipment sales ties in with expansion possibilities for microwave relay sales. One large aircraft concern reports that a number of its plants, at differing locations, are linked together by relay units; and the computers are kept chattering to each other continuously. The expansion of this type of business will depend on equipment reliability factors and reduction of installation expense. Increasing concern is being expressed over outages and downtime due to the complexities of data processing and computing equipment.

Uses of microwave relay units for utility companies is increasing, but similarly, concern is being expressed about outages due to equipment downtime for various reasons. Thus, many and varied uses of these links will present a strong growth market in this period.

From our analysis of interests and markets for relay communications, we can foresee world communication needs being met by these techniques. As the underdeveloped nations of the world struggle to achieve their national aspirations, one of the first requirements of their emergence into twentieth century trade will be a communication network. This will not happen overnight, but the growth trend will be upward. This will be a positive factor for microwave equipment in the foreseeable future.

Interest in millimeter band activity is also increasing. Despite technical problems, we have seen an increase in

(*Continued on page 38*)

MANUAL AND AUTOMATICAL WAVEGUIDE SWITCHES

SIVERS LAB have a long experience of waveguide switches, both manual and automatical types. The newest designs are still more improved both mechanically and electrically and provide an ideal solution for high and low power microwave systems.

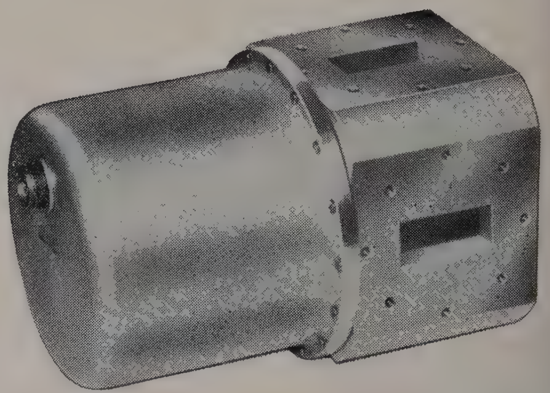
The automatical types have been designed for use where very fast switching is required e.g. for reversal, standby and for measurements in radio links and in modern broadband radar systems fitted with two magnetrons.

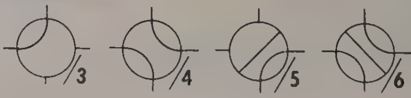
Automatical switches employ for very FAST SWITCHING a spring which is rewound after each operation by means of a motor. REMOTE INDICATION is provided.

The LOW VSWR of less than 1.05, in some types below 1.02, makes both types suitable in laboratory use to speed-up tests on microwave tubes and components.

The ISOLATION between different channels is at least 80 dB up to more than 100 dB over the whole frequency band. This makes testing of radar stations possible without disclosing frequency or geographical situation.

SIVERS LAB manufacture high precision microwave instruments and components. Write for complete catalog.





Available types	Frequency range kMc/s	Waveguide type No.
SL 5980/41/51/42/52	2.6 — 3.95	WR284
SL 7490/41/61/42/62	3.3 — 4.9	WR229
SL 5990/41/61/42/62	3.95 — 5.85	WR187
SL 7010/41/61/42/62	5.85 — 8.2	WR137
SL 7020/41/61/42/62	7.05 — 10.	WR112
SL 5600/41/61/42/62	8.2 — 12.4	WR 90
SL 7030/41/61/42/62	12.4 — 18.	WR 62

First suffix means circuit as above. Second 1 or 2 mean manual or automatical type.

Price example: SL 5600/61 $155.00 f.o.b. Stockholm

SIVERS LAB

Box 42018
Stockholm 42
Sweden

Elektravägen 53
Phone: 18 03 50
Cable: Siverslab

Cast Waveguide COMPONENTS

complete line of high quality cast waveguide components is now available from Microwave Associates, Inc. nits for use at frequencies from 1.2 to 40 kMc are electrically and mechanically interchangeable with similar units u may now be using. • Delivered from stock, they may be specified in either Beryllium Copper or Aluminum.

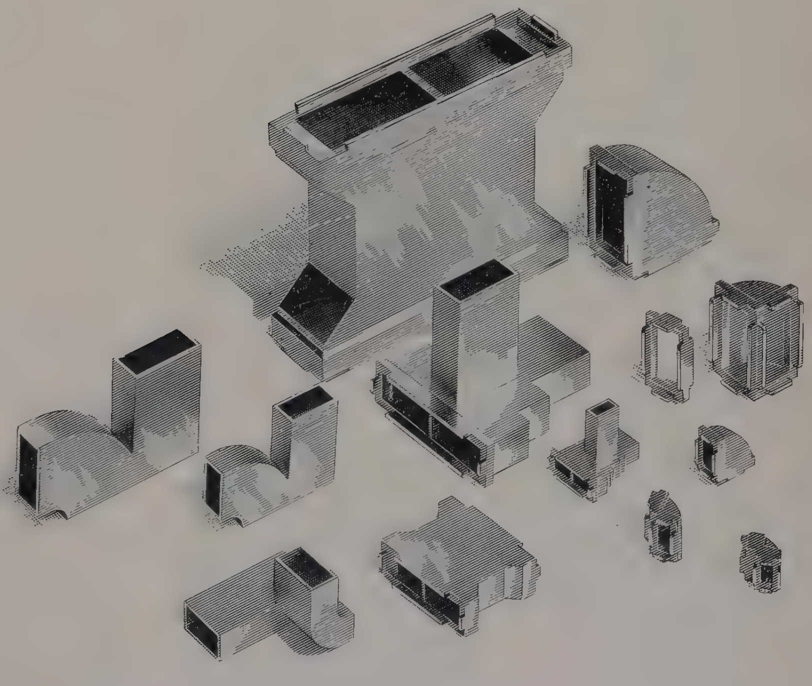
ICROWAVE ASSOCIATES, INC. Component Division

URLINGTON, MASSACHUSETTS • BROWNING 2-3000 • WESTERN UNION FAX • TWX: BURLINGTON, MASS. 942

icrowave Associates' Components Division also manufactures over 750 waveguide components. These include pressure windows, test equipent, specialized waveguide components such as balanced mixers, harmonic multipliers, and complete microwave sub-system packages.

EXPORT SALES: MICROWAVE INTERNATIONAL CORP., 36 W. 44TH ST., N.Y.C., N.Y., U.S.A., CABLE: MICROKEN

VISIT US AT THE
IRE SHOW
Booths 2302-2304



COMPENSATED CAST BENDS • WAVEGUIDE-TO-WAVEGUIDE COUPLINGS • "PANTY" ADAPTERS
E/H AND STRAIGHT ADAPTERS • FOLDED HYBRID TEES • SIDEWALL HYBRID COUPLERS

Circle Reader Service Card 25

Applied Research inc.

LOW NOISE RF AMPLIFIERS

NOISE FIGURES

LESS THAN ◀ **1 DB at 30 MC**
3 DB at 300 MC

No Blowers

No Critical Alignment

Amplifier Model UH-2(A)SP is available at any preset frequency between 30 and 300 MC. This amplifier is a two tube unit with broadband response, high gain, and low noise figure. The unit requires no additional air cooling supply, as natural ventilation is used. The amplifier and its power supply are assembled on a 19" L x 3½" H panel suitable for rack mounting. Small size and low weight are featured in the rugged amplifier chassis.

Specifications of the amplifier are given below.

SPECIFICATIONS—MODEL UH-2(A)SP AMPLIFIERS

Frequency range:	Center frequency between 30 MC and 300 MC
Bandwidth:	Up to 10% of center frequency
Gain:	Greater than 20 DB (function of freq. and BW)
Noise figure:	<1 DB at 30 MC to <3 DB at 300 MC (function of freq. and BW)
Source impedance:	50 ohms
Output impedance:	50 ohms
Connectors: input	Type BNC, or N
output	Type BNC, or N
power	2 prong motor base receptacle
Power requirements:	115 VAC, 60 cps, 25 W
Dimensions:	19" L x 3½" H x 6½" D
Weight:	12¾ lbs.
Finish:	Gray enamel panel

For additional information write

Applied Research inc.

76 South Bayles Avenue, Port Washington, N. Y.

BAZZY

(*Continued from page 36*)

dollar volume over the last year. Millimeter component sales are still under a million dollars, in all probability. One of the hindrances to the more rapid development of these upper frequencies has been the limited availability of millimeter tubes. Several tube manufacturers have started development programs in this band. We have seen a recent study by The Microwave Power Tube Division of The Raytheon Company on "Millimeter Waves—The New Frontier." Frank Lynn, Applications Engineer, on assignment by the Director of the Spencer Laboratory has prepared a company report on this field. The general conclusions reached are that "research has progressed sufficiently so that the frontier for practical devices has been extended to frequencies of 100 kMc." Realistic plans may be made for the development of frequencies of 300 kMc. (1 millimeter).

Millimeter wavelengths can be used advantageously in communications equipment. For instance a ten per cent bandwidth at 100 kMc is sufficient to carry all of the telephone conversations going on at "one time" in the U.S. This is especially appealing also for high information rate data links. Present equipment capabilities allow bandwidths broad enough to handle over 200 simultaneous color television channels or ten million teletype channels. This improvement in productive capacity over current techniques has strong economic appeal.

Space communications needs can best be met through the use of millimeter wavelengths, since atmospheric absorption does not exist in space, and the weight reduction problem is attractive to the engineer.

The work at Lincoln Laboratory by Lax and Heller on these frequencies lends weight to their appeal for possible solutions to problems of the crowded communication spectrum. We hope to feature papers in the near future which explore these bands.

It is not our intention to paint a blue skies picture which will conclude that all is rosy for the average microwave firm. We do realize that this industry is still in its formative stages. Microwave techniques play a dominant role in many of the country's major military systems and the outlook for commercial activities is excellent.

Competitive problems have increased for many microwave firms. Certainly it is no longer a problem "to whom should we allocate these components?" but "how can we sharpen our sales technique?" Since *the microwave journal* first started in 1958, we have seen many firms double their annual gross sales. While the profit margins have been under pressure, the economic situation is not as severe as in other segments of the electronic complex.

the microwave journal has enjoyed a commensurate growth pattern in its service to the microwave industry. We have traveled the length and breadth of the country, exploring microwave activities and making friends. Our Board of Editors, under Ted Saad's direction, has kept *the microwave journal* a publication for and by the engineers. *the journal* will attempt to service the industry in the days to come by keeping abreast of market activities in addition to the engineering developments that are coming from the laboratories.

ndustry News

RADAR "PENTHOUSE" OVERLOOKS MANHATTAN

A radar-equipped penthouse has been commissioned eleven lecks" above Battery Park at the lower end of Manhattan Island. Raytheon Co., Waltham, Mass., will operate the "SS Penthouse" as a demonstration and training center for shipmasters and operating officials.

Located atop 17 State Street, the new installation includes a model 1450 marine radar and a true motion accessory. The radar devices present two different presentations: the usual relative motion display found most radars as well as the newer true motion concept. As modern shipboard installations the two units are installed longside each other and are operated from the same 12-foot ntenna.

Within the 40-mile range of the radar are all of Upper ew York Bay, the Narrows, and the lower Hudson River. isitors and trainees can see the shadowy "wakes" behind he ship targets as they move across the scope. The tails beind the targets are made by afterglows of infra-red energy n a special memory tube which stores earlier signals.

Master of the new "SS Penthouse" is Harold L. Herndon, aytheon marine sales engineer. Mariners and shoreside oper- ing personnel may call WIsconsin 7-6400 for appointments inspect the new facility.

— *mwj* —

DUFRESNE JOINS VARIAN

Louis J. DuFresne, formerly general sales manager for chlage Lock Company, has joined Varian Associates in the newly-created position of marketing manager for the Tube Group, Palo Alto, Cal.

Working directly with Executive Vice President Emmet Cameron, Mr. DuFresne will be responsible for coordinating marketing efforts of the Tube Division at Palo Alto and Varian's subsidiary plants, and for the national advertising and promotion program.

A native of San Francisco, Mr. DuFresne attended both the University of California and Stanford University. He was domestic sales manager at Schlage or eight years and in 1959 was appointed general sales mana- er with overall responsibility for Schlage's international mar- eting effort.

— *mwj* —

NARDA SIGNS BUILDING PACT

Narda Microwave Corp., Mineola, N.Y., has signed an agree- ent with Axinn & Mascioli, Great Neck, N.Y., to construct new 40,000 sq. ft. plant on a 2 1/2-acre site on the top of ngineers Hill in Plainview, N.Y.

The plant, which will double Narda's present capacity, is xpected to be ready for occupancy late in the summer of 961. Bernard Markus of Island Realty Company, Mineola, andled the transaction.

Irving J. Hirschman, A.I.A., of Westbury, N.Y., has been ppointed architect for the new plant. Preliminary plans call or the construction of a modern, fully air-conditioned build- ng with a two-story office and laboratory block and a one- tory manufacturing and assembly area. The site provides mple parking space for 300 employees' cars.

— *mwj* —

(*Continued on page 40*)

Circle Reader Service Card 27

A Symbol to Rely Upon...

The Microwave Dynamics trademark has come to represent a standard of achievement of unique custom capabilities which have improved the state-of-the-microwave-art in advanced systems and components.

Expressed in a growing line of custom and proprietary products, this standard is set by an outstandingly qualified staff of engineers, met by the close-tolerance tooling and careful craftsmanship of a highly flexible production facility, and maintained by the most exacting quality control and testing procedures obtainable.

To date, the successful combination of creative capability and custom craftsmanship at Microwave Dynamics has been responsible for the development of:

- **Custom High-voltage Laboratory and Airborne Power Supplies:** . . . from 10,000 to 50,000 vdc.
- **Model 500 Microwave Power Supply:** . . . featuring an integral mode-displaying oscilloscope.
- **Model 515 Klystron Power Supply:** . . . with excellent ripple and regulation to accommodate medium voltage tubes.
- **Precision Millimeter Components:** . . . from 5 mm to 2 mm.
- **Microwave Components:** . . . an extensive line — from 300 to 300,000 Mc/s.

A Name to Watch

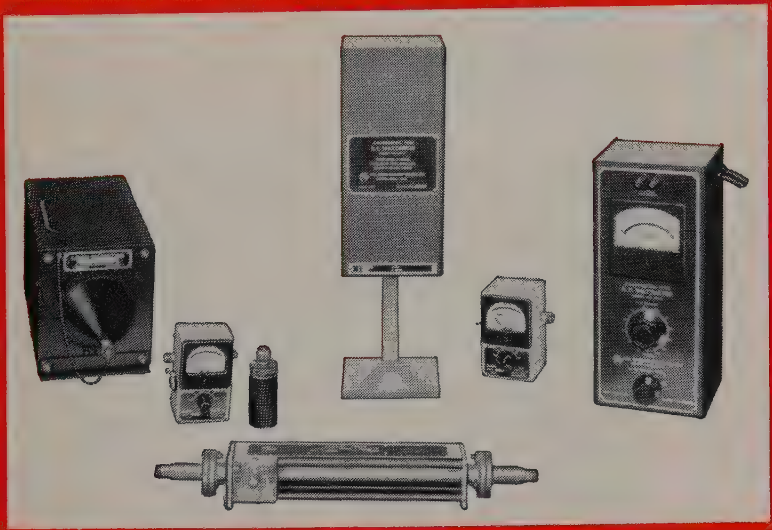
Coming soon . . . a major advance in the field of microwave instrumentation . . . Microwave Dynamics will soon introduce a new electronic testing device, two orders of magnitude improved over any such equipment now in existence. Look for this important announcement in the May issue.

A Symbol of Reliability in the Microwave Field

MICROWAVE DYNAMICS CORPORATION
a subsidiary of Talley Industries, Inc.

MicroMatch®

RF POWER STANDARDS LABORATORY



MicroMatch equipment is used to establish a reference standard of RF power to an accuracy of better than 1% of absolute.

THE 64IN CALORIMETRIC WATTMETER establishes RF power reference of an accuracy of 1% of value read, and is used to calibrate other wattmeters. Five power scales, 0-3, 3-10, 10-30, 30-100, and 100-300 watts, are incorporated in the wattmeters for use in the 0-3000 mcs range.

711N and 712N FEED-THROUGH WATTMETERS, after comparison with the 64IN, can be used continuously as secondary standards and over the same frequency range as covered by the primary standard. The MODEL 711N is a multirange instrument covering power levels from 0 to 300 watts in three ranges, 0-30, 30-75, and 75-300 watts. MODEL 712N covers power levels of 0 to 10 watts in three switch positions, 0-2.5, 2.5-5, and 5-10 watts full scale.

636N and 603N RF LOAD RESISTORS absorb incident power during measurements. MODEL 636N is rated at 600 watts, and MODEL 603N is rated at 20 watts. Both models perform satisfactorily over the entire frequency range to 3000 mcs. These loads, in conjunction with the MODELS 711N and 712N Feed-through Wattmeters, form excellent absorption type Wattmeters.

152N COAXIAL TUNER is used to decrease to 1.000 the residual VSWR in a load. The tuner is rated at 100 watts, and its frequency range is 500-4000 mcs.

For more information on Tuners, Directional Couplers, R. F. Loads, etc., write

M.C. Jones

M. C. JONES ELECTRONICS CO., INC.

185 N. MAIN STREET, BRISTOL, CONN.

SUBSIDIARY OF THE Bendix CORPORATION

Circle Reader Service Card 28

Industry News

(*Continued from page 39*)

FELDMANN RESUMES PRESIDENCY OF FXR

Henry Feldmann, a founder and board chairman of FXR, Inc., Woodside, N. Y., a manufacturer of microwave test instruments and associated equipment, has resumed the presidency of the company, succeeding Tore N. Anderson, who has resigned to form his own consulting business in the microwave field.

Mr. Feldmann, who had been in poor health when he turned over the presidency to Mr. Anderson a few months ago, is now fully recovered, the FXR announcement said, and he is prepared to run the daily operations of the company as well as continue as chairman of the board.

Mr. Anderson, formerly vice president and director of engineering at Airtron, Inc., came to FXR in January, 1960, as assistant to the president. He became executive vice president and general manager in April, was elected to the board of directors in July, and he assumed the presidency in September.

—*mwj*—

PETER JOINS WATKINS-JOHNSON

Dr. Rolf W. Peter has resigned the position of director of the Physical and Chemical Research Laboratory, RCA Laboratories, Princeton, N. J., to become manager of the Electron Devices Division of Watkins-Johnson Co., Palo Alto, Cal.

Dr. Dean A. Watkins, president, announced Dr. Peter will take immediate charge of his firm's activities in microwave tubes and other devices.

Appointed to head Physical and Chemical research in 1957, he was responsible for fundamental and applied research in electronic materials and special image and detector devices and for research activity of Laboratories RCA Ltd. in Zurich. He also represented RCA on the Operating Committee of the Industrial Reactor Laboratories at Plainsboro, N. J.

Dr. Peter is a Fellow of the Institute of Radio Engineers and a member of the American Physical Society and Sigma Xi. He assisted in organizing the annual Electron Tube Conference and the Electron Devices Conference and was chairman of the former in 1957. He holds 16 U. S. patents and has several pending in the fields of microwave tubes and circuits, solid-state devices and electronic systems.

—*mwj*—

(*Continued on page 42*)

ITTON INDUSTRIES
ICROWAVE TUBES
, L, S, C, X, K BANDS

LYSTRONS

ype umber	Frequency Range Megacycles	Peak Power (Minimum) Megawatts	Cathode Pulse Length Microseconds	RF Duty Ratio	Remarks
3270	1250 to 1350	2	8	0.0025	Broadband (100 megacycles between 2 megawatt points)
-7504 -3035)	1240 to 1360	2.2	8	0.0025	Long range search radar
3257	1280 to 1330	4	30	0.0003	For linear accelerator
3227	1280 to 1330	5	8	0.002	For linear accelerator
3250	1250 to 1350	10	7.2	0.0015	Long range search radar and linear accelerator
3387	1250 to 1350	30	7.2	0.0033	Long range search radar
3302	2855	10	7.2	0.0015	For linear accelerator and radar
3355	1250 to 1350	20	7.2	0.0015	Long range search radar

RAVELING WAVE TUBES

ype mber	Frequency Range Megacycles	Power Output	Focusing	Duty Factor
3266	7000 to 11,000	20 mw	PPM	CW
3236	7000 to 11,000	2 W	PPM	CW
3470	4000 to 8000	20 mw	PPM	CW
3471	4000 to 8000	2 W	PPM	CW
3472*	8500 to 9600 7000 to 11,000	10 W 5 W	PPM	CW
3264*	100 to 300	100 W	Solenoid	CW

In development

-TYPE BACKWARD WAVE OSCILLATORS

ype mber	Frequency Range Megacycles	Power Output	Focusing	Factor	Remarks
-3148	8500 to 11,000	150 watts minimum	Permanent magnet	CW	No holes in a 1.5/1VSWR

complete line of M-BWO's is available but classified

PULSE MAGNETRONS

Type Number	Frequency Range Megacycles	Peak Power (Min.) KW	Duty Ratio	Remarks
L-3204	8800±25	0.04	0.25	Extremely high duty
L-3105	9300±40	0.10	0.027	Highly ruggedized; frequency stable
L-3028	9280 to 9320	0.12	0.027	Frequency stable; pulse train capability
L-3379	8800 to 9500*	1.0	0.003	Highly ruggedized; frequency stable
L-3058	9330 to 9350*	1.0	0.003	Frequency stable
L-3358	16,000 to 16,500*	1.0	0.001	Highly ruggedized; frequency stable
L-3380	8800 to 9500*	2.0	0.002	Highly ruggedized; frequency stable
L-3359	16,000 to 16,500*	2.0	0.001	Highly ruggedized; frequency stable
L-3381	8800 to 9500*	3.0	0.001	Highly ruggedized; frequency stable
L-3382	8800 to 9500*	4.0	0.001	Highly ruggedized; frequency stable
LT-6233	9280 to 9345	7.0	0.003	High duty beacon magnetron
L-3103	8500 to 9600*	30.0	0.002	High duty version of LT-6543
L-3168	9375±30	30.0	0.002	High duty version of LT-4J52A
L-3306	16,000 to 17,000*	30.0	0.002	High duty version of L-3083A
L-3083A	16,000 to 17,000*	60.0	0.001	Recommended for new systems
LT-6543A	8500 to 9600*	65.0	0.001	Recommended for MTI systems
L-3305	8600 to 9500*	65.0	0.001	Recommended for frequency diversity
LT-6510	9375±30	65.0	0.001	Recommended for MTI systems
LT-4J52A	9375±30	70.0	0.001	Recommended for new systems
L-3312	8500 to 9600*	200.0	0.001	In development
L-3313	8600 to 9500*	200.0	0.001	Hydraulically tunable for frequency diversity
LT-4J50A	9375±30	225.0	0.001	Recommended for new systems

**Fixed frequency versions available generally throughout tunable range.*

CW MAGNETRONS

Type Number	Frequency Range Megacycles	Minimum Power Watts	Remarks
L-3456	350-590	500	These CW Magnetrons may be pulsed to approximately 2 kilowatts peak power and are recommended for component testing.
L-3459	590-975	500	
L-3465	975-1500	400	
L-3464	1500-2350	400	
L-3460	2350-3575	500	
L-3461	3575-4975	400	
L-3467	4975-6175	400	
L-3468	6175-7275	300	
L-3462	7275-8775	300	
L-3463	8775-10,475	250	

OSSED-FIELD FORWARD WAVE AMPLIFIER TUBES • BARRATRON® TRANSMITTING TUBES • MINIATURE NOISE SOURCES • DUPLEXERS & TR TUBES • DISPLAY TUBES

"CAPABILITY THAT
CAN CHANGE
YOUR PLANNING"

LITTON INDUSTRIES
Electron Tube Division
San Carlos, California

Circle Reader Service Card 29

SHOWN 3 TIMES NORMAL SIZE

RECORDING HEAD FERRITE

Kearfott's new CN-20 nickel-ferrite, specifically developed for recording head applications, is a sintered material which operates most efficiently in the 10 kc to 750 kc frequency range. CN-20 imparts superior magnetic and mechanical properties, is insensitive to mechanical stresses of potting compound during curing, is magnetically stable under temperature variation and has uniform magnetic properties. CN-20 heads have negligible deviations in inductance to temperatures as high as 160°F, using gaps of .0010 or .0015 inches.

Production quantities of complex shapes are immediately available. Dimensional tolerances of 0.0001 inch and finishes of 16 to 32 micro-inches are standard ... electroplated surfaces for unusual wear resistance also available.

TYPICAL CHARACTERISTICS

Initial Permeability at 100 kc	800
Saturation Magnetization (DC) at 16 oersteds	3680 gauss
Residual Magnetization	2565 gauss
Coercive Force	0.19 oersteds
Temperature Coefficient of Initial Permeability (−20°C to +100°C)	1.0% °C
Curie Temperature	150°C
Resistivity	10^4 ohm-cm

All magnetic properties are held within a tolerance of ±15%

Write for complete data

KEARFOTT DIVISION
GENERAL PRECISION, INC.

Little Falls, New Jersey

Industry News

(*Continued from page 40*)

APPLIED MICROWAVE CONSTRUCTION BEGUN

Plans for the construction of a $100,000 modern office and laboratory building for Applied Microwave Electronics, Inc., in Baltimore County, Md., have been announced by J. Kelsey Burr, 3rd, president.

Construction of the new facilities is expected to be completed by June 1. The contractor is Henry A. Knott, Inc., of Baltimore.

The new plant, featuring a low silhouette facade of screen block and glass, was designed by Cicero H. Brown, Baltimore architect. The building, covering 6,000 square feet, is so designed as to facilitate the testing of microwave antennas on the roof.

Mr. Burr said the site, in the Meadows Industrial Park, was selected because of its proximity to the Baltimore Beltway, providing ease of accessibility, and because of the unusual topography necessary for antenna testing facilities.

—*mwj*—

CENTRAL STATION FLUID COOLER COOLS ELECTRONIC CONTROLS

The first of twelve central station fluid cooler units for use in the SAGE air defense system was recently shipped from the Columbus plant of American-Standard Industrial Division. The equipment is designed to cool electronic controls for a large radar system (known as AN/FPS-24) developed and produced by General Electric Co., Heavy Military Electronics Department, Syracuse, N. Y. for the U. S. Air Force.

The prototype of this advanced system is installed at an Air Force site near Eufaula, Ala. When placed in operational use, it will supply radar information to the SAGE continental air defense system.

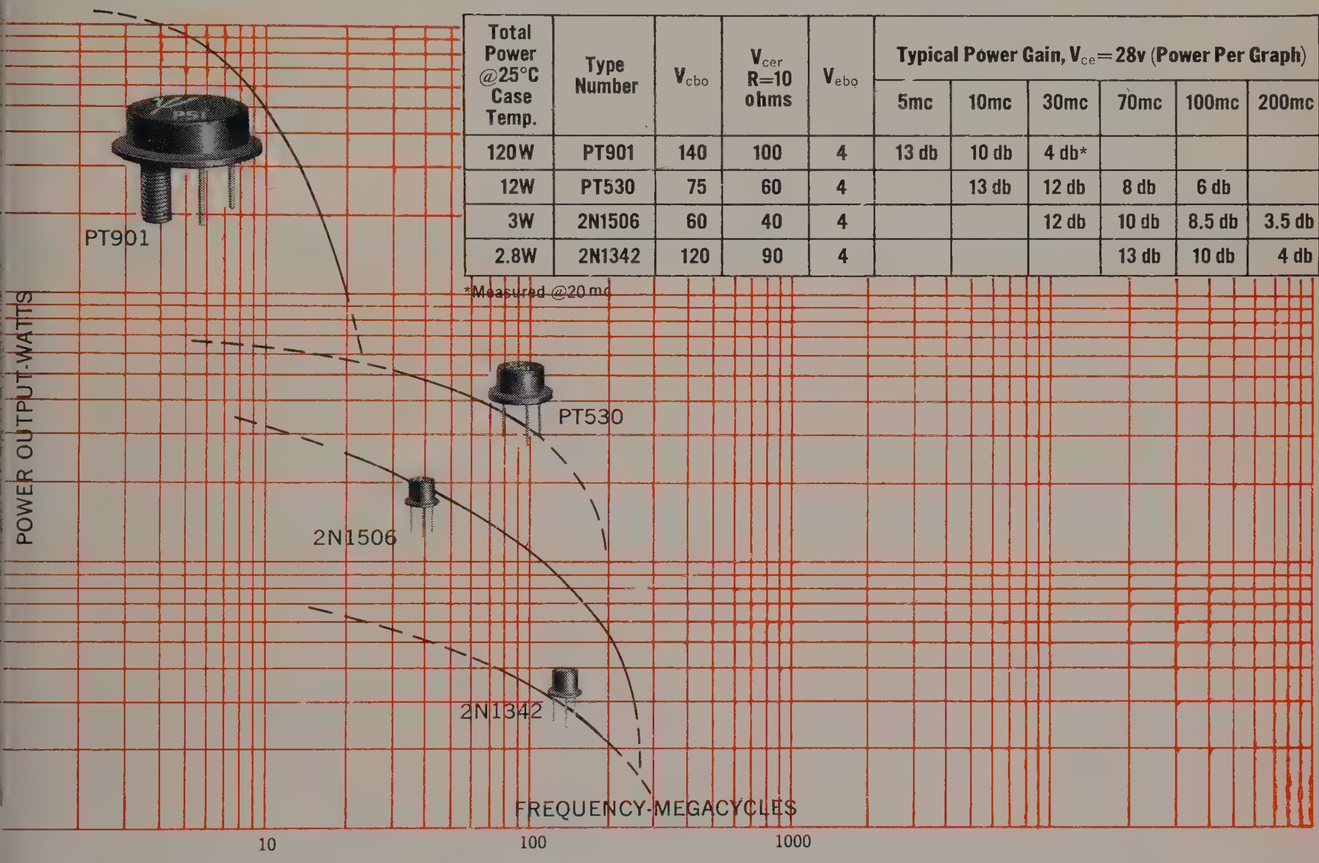
The cooling equipment is basically an evaporative cooler sprayed coil unit combined with a hydraulic recirculating pumping system and suitable piping and

(*Continued on page 46*)

FROM .2 WATT TO 120 WATTS ...FROM 5 MC TO 225 MC

a PSI POWER AMPLIFIER FOR EVERY APPLICATION!

his Great New Line of Triple Diffused Silicon Mesas Provides Transistor for Almost Every Communications Need!



Total Power @25°C Case Temp.	Type Number	V_{cbo}	V_{cer} R=10 ohms	V_{ebo}	Typical Power Gain, $V_{ce}=28v$ (Power Per Graph)					
					5mc	10mc	30mc	70mc	100mc	200mc
120W	PT901	140	100	4	13 db	10 db	4 db*			
12W	PT530	75	60	4		13 db	12 db	8 db	6 db	
3W	2N1506	60	40	4			12 db	10 db	8.5 db	3.5 db
2.8W	2N1342	120	90	4				13 db	10 db	4 db

*Measured @20 mc

Designers of advanced communications equipment can now take a totally new approach to engineering of high performance transmitters in power and frequency ranges never before possible.

A PT530, for example, will furnish 5 watts RF power output at 30 mc (12 db power gain) or 3 watts at 70 mc (8 db power gain). It is the only silicon transistor capable of driving the PSI type PT901 power amplifier transistor to its full 100 watts output. The new 2N1342 furnishes a substantial amount of power for the designer working in the UHF region ... 200 mW RF output at 225 mc.

There are lower cost oscillator versions of the above types, too. The 2N1505 performs admirably in a circuit where you don't need the high gain characteristics of the 2N1506.

Immediate delivery is being made on evaluation quantities of types PT530 and PT901. Large quantity delivery is being made on all other PSI communications and switching transistors ... including the remarkable new 2N1837 high performance switch.

PHONE, WIRE OR WRITE ANY PSI SALES OFFICE FOR FULL DETAILS.

Pacific Semiconductors, Inc.

A SUBSIDIARY OF THOMPSON RAMO WOOLDRIDGE, INC.

12955 CHADRON AVENUE • HAWTHORNE, CALIFORNIA • TWX: HAW CAL 4270

Facilities in Hawthorne, Culver City and Lawndale, California

Circle Reader Service Card 31

OUTSTANDING LATITUDE OF PERFORMANCE

EXCEPTIONAL CHOICE OF OPTIONS

VARIAN 6-INCH

Quality that passes both high-field and wide-gap tests

The two accompanying field plots show the wide latitude of performance of the Varian 6-inch magnets: a large area of homogeneous field at moderate field strength and wide air gap; a small, but usable area of homogeneous field even at strengths as high as 17,000 gauss. In addition, an equivalent degree of time stability is provided by the matching Varian power supply. All these aspects of performance demonstrate the depth of technology behind Varian Magnet systems.

Useful differences in the choice of models

Rotation of the magnetic field about the vertical axis is a capability provided by the rotating V-4007-1. Also, for higher fields this model will accept the full 2 ampere output of a larger optional power supply, the V-2100B. Varian's other 6-inch magnet, the fixed-azimuth V-4007, is lower in cost, provides a wider selection of gap widths, and has an adjustable yoke that permits convenience and flexibility of access to the gap. Varian also offers rotating and fixed-azimuth 12-inch magnet systems.

Pole-cap options to meet varied requirements

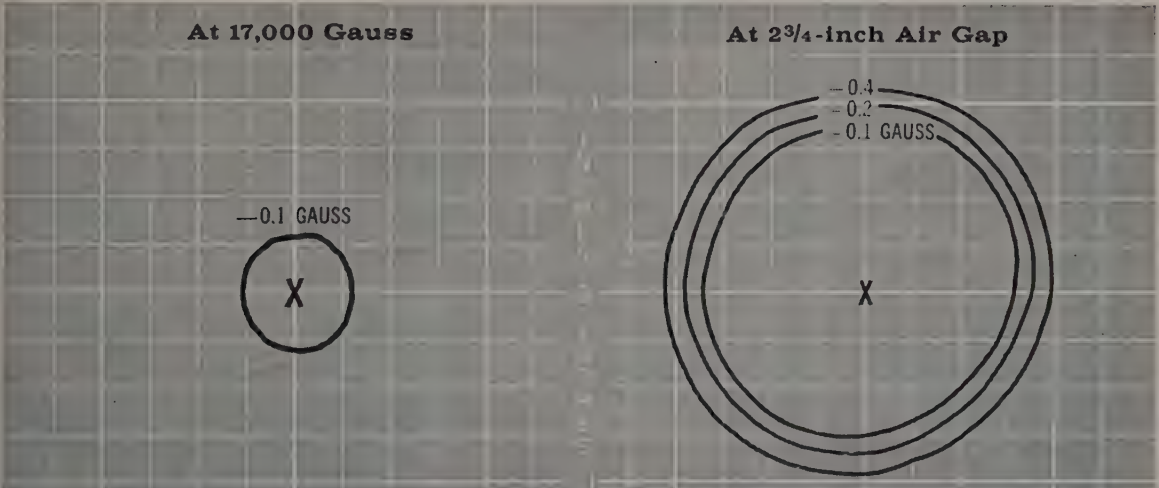
Choice of pole caps available includes cylindrical, tapered, adjustable ring-shim and constant gradient types. Highest fields are provided by tapered pole caps. Largest homogeneous volume is available with the adjustable ring-shim type. Various gap widths on the V-4007-1 rotating magnet are provided by a choice of pole cap thicknesses. On the V-4007 the gap is varied by separating the yoke with pairs of precision ground spacer blocks.

V-2200A regulated magnet power supply

V-4007 fixed azimuth 6-inch magnet

V-4007-1 rotating 6-inch magnet

ABORATORY MAGNETS



At 17,000 Gauss

At 2¾-inch Air Gap

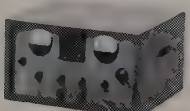
Full-scale plot of homogeneous field in 0.75-inch air gap and 17,000 gauss field on a Varian 6-inch electromagnet with tapered pole caps of 4.0 inch face diameter. Plot taken in median plane of air gap.

Full-scale plot of homogeneous field at 4,600 gauss on a Varian 6-inch electromagnet with adjustable ring-shim pole caps and a central air gap of 2.75 inches. Plot taken in median plane of air gap.

Delivery 30 to 45 days after receipt of order can be provided on most magnet systems.

For full specifications on the Varian Magnets, write the **Instrument Division.**

Varian NMR Fluxmeter provides precise measurement and/or control of magnetic fields, as an accessory to the Varian 6- and 12-inch magnet systems.



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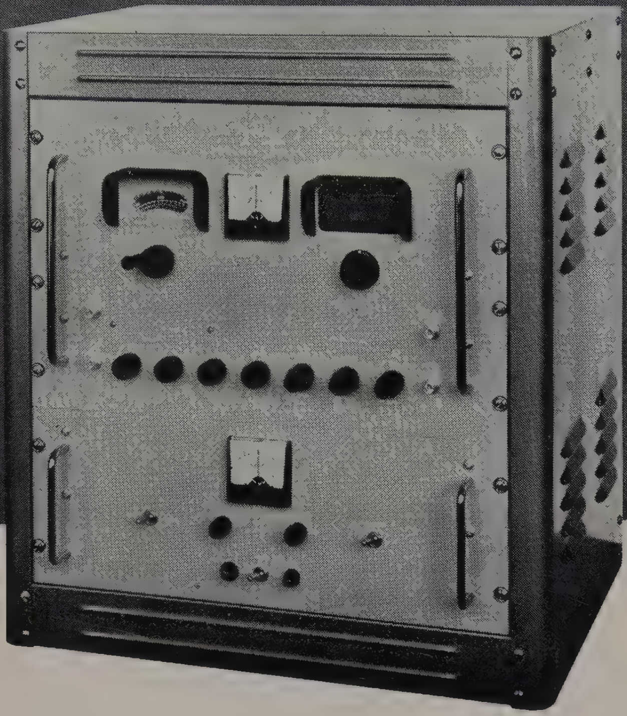

PATTERN PROBLEMS?

Here's a new microwave receiver designed specifically for antenna pattern measurements.

This high sensitivity, lightweight microwave receiver finds its specific application in antenna pattern measurement problems where, by replacing conventional bolometer detectors, sensitivity increases of 30 db to 50 db are realized. Here are some of its salient features:

- Compact, lightweight
- Single dial tuning
- 60 db recording output without modification
- Frequency range from 30 MC to 100 KMC
- Local oscillator tube domestically replaceable at low cost

Write direct or contact us personally in Booth No. 3233-3235 at the New York IRE Show.

- Antenna Pattern Recorders
- Servo Controlled Antenna Mounts
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ANTLAB, Inc.

6330 Proprietors Road Worthington, Ohio TU 5-5396

Circle Reader Service Card 33

Industry News

(*Continued from page 42*)

controls. Using distilled water, it takes heat from electronic equipment and distributes it to the atmosphere. The distilled water is cooled, filtered, de-ionized and pumped back to the electronic equipment for continued cooling. Six returns are provided from the electronic equipment. The system also includes a heater to prevent coil freeze-up during periods when the equipment might be non-operating.

—*mwj*—

FALES NAMED CHIEF ENGINEER

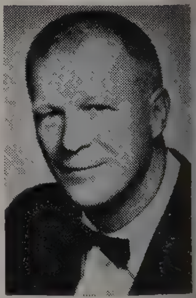
David Fales III has been named Chief Engineer of Gabriel Electronics, Division of The Gabriel Co., Millis, Mass. The announcement was made by John B. Suomala, vice president-engineering.

Mr. Fales was formerly Manager of Electronic Product Sales and Staff Engineer for the Martin Company in Baltimore, Md. Prior to this he was supervisor of the Antenna Design Group at Bendix Radio Division. He has been responsible for all phases of electronic engineering with emphasis on RF Circuitry.

As chief engineer for Gabriel Electronincs, Mr. Fales will be responsible for new design concepts and research and development in all phases of electronics with emphasis on microwave propagation.

—*mwj*—

EASTON NAMED TO NBS ADVISORY COMMITTEE



Ivan G. Easton, vice president for engineering, General Radio Co., West Concord, Mass., has been appointed to an advisory committee on calibration and measurement services, recently established by the National Bureau of Standards.

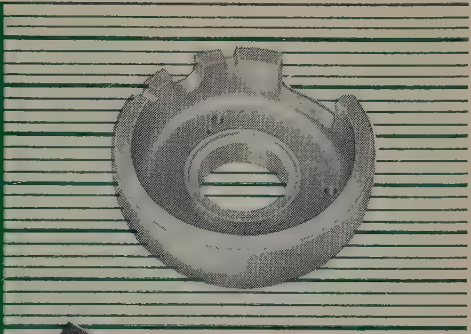
As a liaison between NBS and industry, the committee will serve to coordinate precision measurement, calibration and standardization practices.

Committee members were selected by the director of the Bureau on the basis of their diversified knowledge of calibration and measurement problems encountered in particular segments of industry.

—*mwj*—

(*Continued on page 48*)

ALNICO 5? 7A? 8?
GENOX I? V? VI?



The proper materials and design of permanent magnets are often the key to economy in weight and costs of Microwave . . .

- **FERRITE ISOLATORS**
- **MAGNETRONS**
- **KLYSTRONS**
- **BWO'S**
- **TWT'S**

what are your specifications?

BOOTH 1904

GMC Magnetic Engineers will be available throughout the IRE show hours. There is no obligation —just consult them!

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Guaranteed Magnetic Components
10001 ERWIN AVE., DETROIT 34, MICHIGAN

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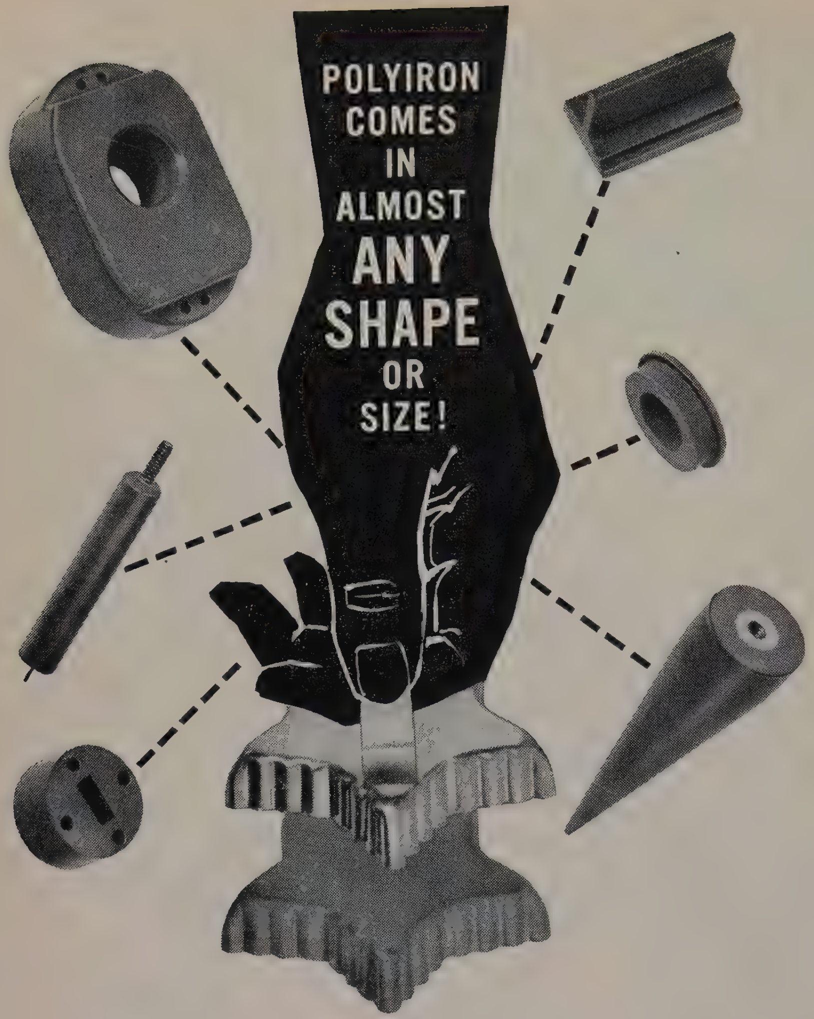

This and Attenuation up to 300 D.B. per Inch Make It the Top Dielectric for Microwave Use

From the original developers of Polyiron come the ideal shapes for countless components for VHF-UHF projects.

Ideal because Crowley Division of A. O. Smith has the necessary facilities to process Polyiron into any size or shape component regardless of contour intricacy. This adaptability covers terminations, wave guide switches, coaxial lines, R.F. gaskets, range extenders for vane-type attenuators and many more. Crowley precision grinds material close enough to satisfy the most critical of these requirements.

Ideal too because few commercial permeable dielectrics can match Polyiron's exceptional electrical and mechanical characteristics. Crowley advantages are: attenuation up to 300 D.B. per inch . . . lower standing wave ratios for greater energy transfer . . . high efficiency at any wave length.

Perhaps you have an attenuation problem that could "shape up" with Polyiron. Write and specify the attenuation desired and our research engineers will assist you in selecting the right Crowley material for your application. Or send for Microwave Components — Catalog No. 260.

Through research . . . a better way

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(*Continued from page 46*)

WHEELER NAMED DEVICE DEVELOPMENT ENGINEER

Alfred J. Wheeler, Somerville, N. has been named Device Development Engineer at Micr State Electroni Corp., Murray Hil N. J. Mr. Whee er's appointme was announced Micro State Pres dent, Dr. Sa Weisbaum an Aaron Kestenbau vice-president Micro State's Semiconductor Product Division.

Micro State specializes in applied research, development and manufacturing i the field of solid state electronics, particularly in the UHF and microwave areas.

Mr. Wheeler received his BS in Physic from Worcester Polytechnic Institute i 1951, after which he served in the Researc and Development Laboratories of th Corps of Engineers, U. S. Army, at For Belvoir, Va.

Previously, Mr. Wheeler was employe as an Engineer in the Advanced Development activity of RCA's Semiconductor an Materials Division. His work with RC was in semiconductor device developmen concentrating on development of silico transistors and gallium arsenide rectifiers tunnel diodes and varactors. He is particularly well known for his important contributions to the development of the gallium arsenide tunnel diode.

Mr. Wheeler received his MS degre in Mathematics from Stevens Institute o Technology. He is a member of the IR and has published several technica papers, including one on "Gallium Arsenide High Temperature Diodes".

—*mwj*—

IRE ELECTS 1961 OFFICERS

At its January meeting in New York the IRE Board of Directors elected si directors to serve on the Board in 196 for a one-year term.

Succeeding the late W.R.G. Baker Stuart L. Bailey, president of Jansky & Bailey, Inc., Washington, D.C., wa elected Treasurer. Haraden Pratt, Engineering Consultant, and Ferdinand Hamburger, Jr., professor and chairman of the Department of Electrical Engineering Johns Hopkins University, Baltimore, Md. were re-elected to the offices of Secretar and Editor respectively.

Alfred N. Goldsmith, consulting engineer and editor emeritus of the IRE, an Patrick E. Haggerty, president of Texa Instruments, Inc., Dallas, Tex. were re-elected as directors. Also elected as director was Daniel E. Noble, vice presiden and director in charge of communications Semiconductor and Military Electronic Divs., Motorola, Inc., Scottsdale, Ariz.

—*mwj*—

(*Continued on page 50*)

PRD *previews/reviews/design notes*

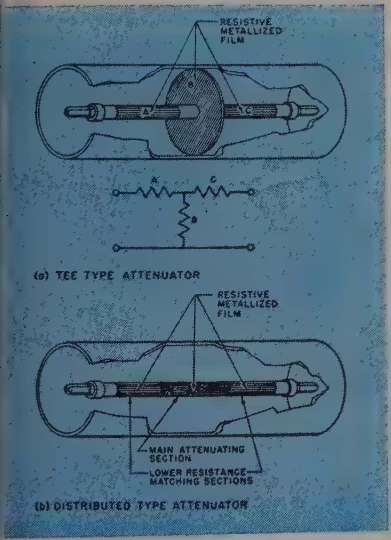
Design Considerations of Attenuators

end use of an attenuator—whether a standard in power or attenuation asurements, a power or signal level uster, an isolator or buffer pad—l, of course, bear on its design. But tain design and construction needs remain constant. Here are some of considerations that go into a PRD nuator.

Attenuating Elements

have found that metallized glass or amic generally make the best resis- elements. They are smooth, chemi-y inert, non-hygroscopic, and will warp or change shape. We apply an remely thin metal film to the element two ways: by "paint" coating and ing, and by high vacuum deposition. baked-on film method proves best coaxial attenuators, and the vacuum position preferable for waveguide.

Fixed Coaxial Attenuators

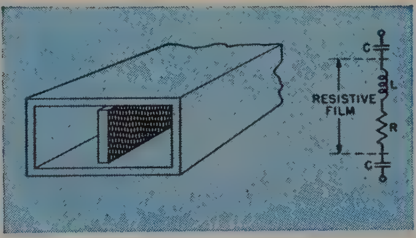

RESISTIVE METALLIZED FILM
B
A
C
A
C
B
(a) TEE TYPE ATTENUATOR
RESISTIVE METALLIZED FILM
MAIN ATTENUATING SECTION
LOWER RESISTANCE MATCHING SECTIONS
(b) DISTRIBUTED TYPE ATTENUATOR

PRD 1100

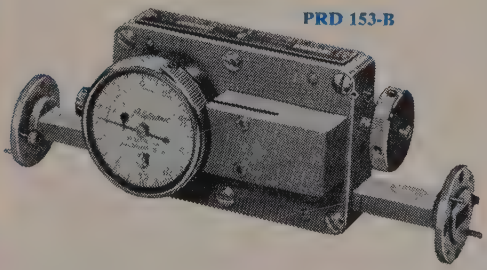
PRD 130

e two basic types of coaxial attenuators produced by PRD are shown ove, in schematic drawing and photographs. The first, represented by the PRD 1100, uses one or more T sections with lumped resistive elements. The distributed type, illustrated by the PRD 130, uses an inner conductor of an electrically long resistive film. The T section PRD 1100 operates best at low frequencies, from dc to 4 KMC; the PRD 130 ranges from 2 to 10 KMC. Both dissipate one watt and are calibrated to ±0.2 db accuracy. The PRD 130 can attenuate up to 20 db; PRD 1100 up to 10 db.

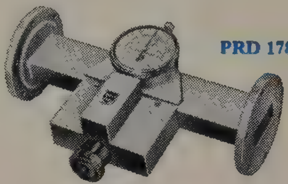
Waveguide Attenuators



The drawing above gives a schematic presentation, with equivalent circuit, of a resistive film parallel to the electric lines in a waveguide. Attenuation is varied by moving the metal-coated glass panel in two usual ways: (1) by lowering it into the waveguide through a slot, as in the PRD 153-B, known as a "flap" type (Freq. range 18.0 to 26.5 KMC; Attenuation to 35 db; Max. VSWR 1.10; Max. insertion loss 0.5 db; Calibration accuracy ±0.2); or (2) by moving the lossy element from the side wall toward the center of the waveguide ...known as the "vane" technique, and illustrated by PRD 178-B (Freq. range 5.4 to 7.2 KMC; Attenuation to 45 db; Max. VSWR 1.15; Max. insertion loss 0.5 db; Accuracy to ± 0.2).



PRD 153-B



PRD 178

Another version of the vane method of attenuation is exemplified by our level set attenuators, such as the PRD 171-B (Freq. range 2.6 to 3.95 KMC; Max. attenuation to 40 db; Max. VSWR 1.15).

PRD 171-B

These are only a few of more than one hundred attenuators produced by PRD and a brief review of the broad design principles involved. For more specifications on these and other units, write for the PRD Attenuator brochure. For design information, write our Applications Engineering Department.

We have many interesting openings for engineers...contact Mr. John R. Zabka

PRD
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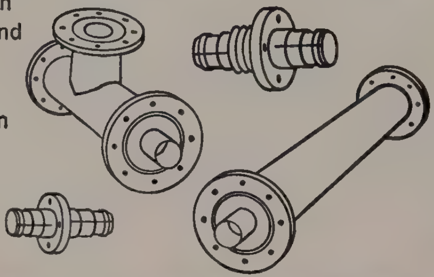
New FROM TACO

MICROWAVE ANTENNA SYSTEMS

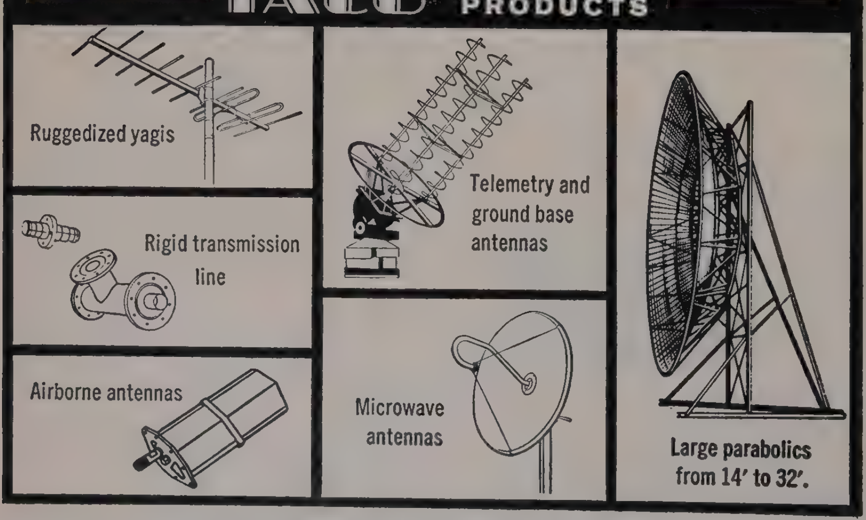
Now, the world's leading designer and manufacturer of fine antenna systems offers microwave antenna systems designed to fill the needs of industry and the military. All popular frequency bands, in all appropriate sizes from 2′ to 12′ diameter. Spun and mesh models. Choice of feed systems for plane or dual polarization. Everything you need for the best microwave antenna installation including mounts, de-icing equipment, and accessories.

RIGID TRANSMISSION LINE

Complete rigid co-axial transmission line systems including EIA flange and Marmon Clamp types. Available in copper or aluminum. Special "THERM-I-FLEX" bullet for long-run aluminum lines. Designed to meet the most critical needs of both military and commercial users. Includes ⅞", 1⅝", 3⅛", 6⅛" and 9" components.



TACO PRODUCTS



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See TACO Booth 1207 at I.R.E.

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Industry News

(*Continued from page 48*)

IRE EXHIBIT PLANS UNDERWAY

One hundred and seven booth spac have been scheduled for the 1961 Techn cal Conference of the Seventh Region the Institute of Radio Engineers ne April 26-28 at Phoenix, Ariz.

Dick Ellstrom, chairman of exhibi announced completion of floor plans f exhibit areas in the Hotel Westward H the conference site, giving close proximi to the technical sessions.

"For the first time in several years these conferences we are able to contai the technical meetings and exhibits in o central location", Ellstrom said. "Th hotel's extensive facilities are admirabl suited to housing total conference activ ties of this magnitude and we have indica tions that the exhibits will be subscribe at an early date."

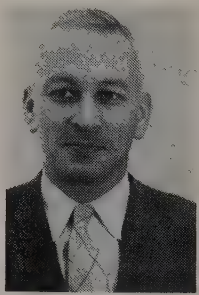
A cost of $150.00 has been establishe for basic exhibit units measuring ten fee in width and seven feet in depth, Ellstro reported. The exhibit hours will be fro 1 to 10 P.M. on April 26 and from 9 t 5 P.M. on April 27 and 28.

An attendance in excess of 2000 is ex pected from the eleven western state represented by the IRE's Seventh Region with other professional leaders (includin the national IRE's board of directors coming from many points across th nation.

Exhibit applications and further detail are available from Dick Ellstrom, Suit 37, 7000 East Camelback Road, Scottsdale Arizona.

—*mwj*—

REICHE WILL MANAGE NEW MELABS BRANCH



Ludwig P. Reiche has been appointe manager of the newly-established Microwave Communications Branch o Melabs, Palo Alto Cal.

Mr. Reiche has been active for ove ten years in the research and development area of radar, communications, and telemetry systems. Prior to joining Melabs, he was a senior research engineer with the Stanford Research Institute. He was graduated from New York University in 1948 with the BEE degree in Communications Engineering; he also pursued advanced studies at the University of California and at the University of Nancy in France.

Mr. Reiche is a member of the Institute of Radio Engineers, and is the author of several papers. He, his wife and their three children live in Palo Alto.

—*mwj*—

(*Continued on page 54*)

MICROWAVE OSCILLATOR STABILITY AND ITS MEASUREMENT

ith emphasis on techniques to measure accurately residual frequency modulation, analyze disturbance frequencies, and determine drift

by R. M. WALLACE

Manager, Instrumentation Section

LABORATORY FOR ELECTRONICS, INC.

nce World War II, the stability reired of microwave oscillators has become ore and more stringent, and with the quirement, the need to measure stability aracteristics. And for the purposes of this scussion, we shall concern ourselves only th measurements on continuous-wave osllators whose frequency is constant within 50 kilocycles per second during whatever riod of time one may wish to measure bility. Specifically, this requirement imies oscillators with some form of external bilization.

icrowave oscillators stable to within a w cycles per second are required day in many diverse fields. Perhaps e oldest and still very important age is as a local oscillator in moving get indicating radar systems. Newer apications include radio astronomy, backatter phase measurements, determining sponse characteristics of narrow-band miowave devices, electron paramagnetic specoscopy, and secondary frequency standards.

all of these, two kinds of instability e of primary concern: residual frequency odulation, as well as its cause, periodic non-periodic, which we call short-term stability; and drift, which is long-term stability. The first dependable instrument measure these instabilities was LFE's 04, marketed in 1955, which still is the ate of the art of competitive stability sters. In 1959, a factor of ten improveent was offered in the Model 5009. nce then, further substantial improveent has resulted in the 5024, to be anunced in March of this year.

ne 5024 is basically a double superhetodyne receiver of extraordinary stability d refinement. To help explain some of performance characteristics, a very simified block diagram is shown below. operation, the crystal oscillator is varied til a harmonic is found which produces 30 mc/s output from the mixer. The lanced mixer together with the last ultiplier of the multiplier chain is a ug-in unit to facilitate band changes. Four eads are currently available covering the equency ranges as follows with the sentivities indicated: 1000 to 3200 mc/s 0 to −35 dbm), 5000 to 6100 mc/s 0 to −25 dbm), 7000 to 10,000 mc/s 0 to −20 dbm), and 9000 to 11,000 c/s (0 to −12 dbm). Other frequency ranges up to Ku band are available on special order.

After amplification at 30 mc/s, the test signal is heterodyned down to 120 kc/s and further amplified. The inputs to both i-f amplifiers are available for direct injection of test signals. Thus 30 mc/s ±50 kc/s, as well as 120 kc/s ±50 kc/s signals can be analyzed.

In the 2nd i-f amplifier, each stage is a cathode-coupled amplifier which is resistance-capacitance coupled to the next. Because of extreme limiting, the sinusoidal input is converted to very steep-edged square waves. These output pulses are then differentiated, and the positive-going spikes are used to trigger a blocking oscillator which, by means of a delay line, generates square-edged pulses of extremely constant amplitude and duration. There is one constant-energy pulse for each cycle of sinusoidal input to the 2nd i-f amplifier.

It is important to note that, up to this point, the double conversion employed to reduce the input signal to quantized pulses at 120 kc/s does not affect the error information of frequency drift or frequency modulation, provided that the input signal is sufficiently stable to remain within the 70 to 180 kc pass band of the 2nd i-f amplifier. Thus frequency variations (error information) have not been changed. Beyond this point, however, frequency variations are converted to voltage variations.

Now, if the amplitude of these constant-energy pulses is E and the width is t, then the average output voltage E_o as read on a d-c voltmeter is $E_o = E\ t\ f$, where E and t are constant and f is a frequency in the 2nd i-f pass band. By simply providing a bucking voltage equal to the E_o at the center of the pass band (120 kc), a zero-center meter can be used to read drift, plus or minus, about the frequency at the start of a test. On the 5024, two drift ranges are supplied: ±50 kc/s and ±5 kc/s, the latter with a separate zero-adjust control. A BNC jack is also provided for recording long-term drift.

If frequency modulation of the input signal is present (short-term instability), there is an a-c component superposed on the average d-c level, E_o. F-M deviations exist here as jitter of both the leading and trailing edges of the quantized pulse train, pulse length remaining constant. The magnitude of the a-c component is $dE_o = E\ t\ df$.

To recover this component for display as peak f-m deviation, the quantized pulse train is put through a low-pass filter to remove the 120 kc/s carrier and all higher frequencies. Removal of the carrier and higher frequencies leaves only the disturbance frequencies. Five pass bands can be selected: 10 to 150 cps, 10 to 500 cps, 10 to 1500 cps, 10 to 10,000 cps, and 10 to 20,000 cps. All band widths are measured at the 3 db points.

After amplification and detection, the filter output is fed to a meter on the front panel which is calibrated to read peak deviation. Eight full-scale ranges are provided: 10, 30, 100, 300, 1000, 3000, 10,000, and 30,000 cps. A BNC jack is provided for observation by means of an oscilloscope to help determine the nature and hence the origin of the disturbance frequencies.

A separate tunable filter is also available for spectrum analysis of the disturbance frequencies. This filter, or wave analyzer, is tunable from 10 to 10,000 cps, in three ranges, tuning range measured between 1.5 db points. Its Q is 50 across all bands.

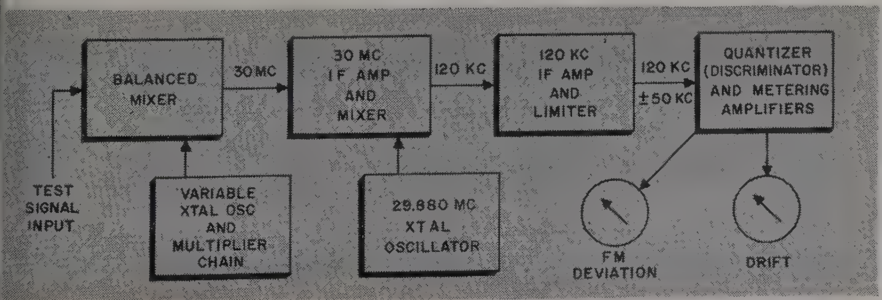
When the tunable filter is used and with reasonable care, the minimum measurable f-m deviation is as follows:

0.2 cps at 30 mc/s and 120 kc/s,
0.3 cps at L band,
0.5 cps at S band,
0.7 cps at C band,
1.5 cps at X band, and
2 cps at Ku band.

The principal advantages of the 5024 over the older 5009 are in the widening of the dynamic operating range of f-m deviation, plug-in heads reduced in cost to about one-third of previous heads, Epsiline (etched circuit) plumbing through C band, and updating of all circuits. And in addition, the 5024 is smaller and lighter.

An interested reader can obtain much more detailed information by requesting Bulletin 5024. For this bulletin, or the answers to particular questions, write Mr. Perry Pollins at the address below.

LABORATORY FOR ELECTRONICS, INC.
Instrument Division
714 Beacon Street, Boston, Massachusetts


BALANCED MIXER
30 MC
30 MC IF AMP AND MIXER
120 KC
120 KC IF AMP AND LIMITER
120 KC ±50 KC
QUANTIZER (DISCRIMINATOR) AND METERING AMPLIFIERS
TEST SIGNAL INPUT
VARIABLE XTAL OSC AND MULTIPLIER CHAIN
29.880 MC XTAL OSCILLATOR
FM DEVIATION
DRIFT

See the Model 5024
at the IRE Show,
March 20-23,
Booths 3819 and 3821

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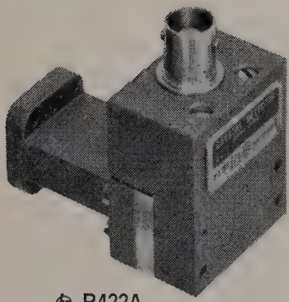
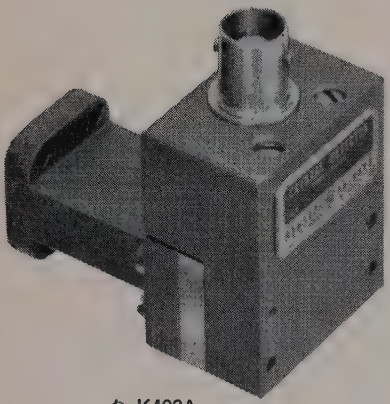
Complete RF Detector

Two new hp developed mounts offer unique combination of wide band-width, low SWR and high sensitivity for general-purpose and reflectometer uses!



hp R422A



hp K422A

Flat frequency response and excellent sensitivity for rf detection are yours with the new hp K422A (18 to 26.5 GC) and R422A (26.5 to 40 GC) Waveguide Crystal Detector Mounts.

These broadband instruments cover the frequency range 18 to 40 GC, and provide the same excellent square-law detection characteristics as lower frequency hp crystal mounts. The unique advantages of the 422A are made possible by hp design and production of the internal crystal and the detector mount as an integrated unit.

hp 422A extends the coverage of hp coaxial and waveguide rf signal detectors while maintaining low SWR and high detection efficiency. General-purpose rf detector uses include mixer applications. Excellent frequency response (± 2 db maximum full range) and true square-law characteristics make the hp mounts ideal for swept-frequency reflectometer applications extending to 40 GC.

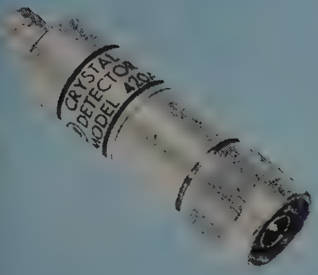
SWR: Less than 2.5. Sensitivity: .05 v per mw. Square law characteristics: ± 1 db (—3 dbm to —40 dbm).

hp K422A, 18.0 to 26.5 GC, $200.00; hp R422A, 26.5 to 40 GC, $200.00.

hp®

WORLD LEADER IN PRECISION WAVEGUIDE INSTRUMENTATION!

Coverage to 40 GC!

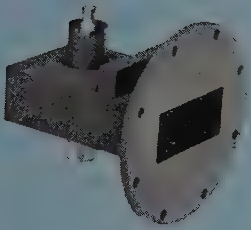


hp 420A Coaxial Crystal Detector Mount, 10 MC to 12.5 GC

Detects rf signals over a three decade frequency range from 10 MC to 12.5 GC. Sensitivity is approximately 0.01 v/0.1 mw, and frequency response is ± 3 db over the full range. Maximum SWR is 3:1. hp 420A, $50.00.

hp 420B Coaxial Reflectometer Mount

Identical to the hp 420A in frequency range, the hp 420B is available in pairs matched to within ± 1 db over the range 1 to 4 GC. hp 420B, $75.00; $150.00 per matched pair.



hp 485 Waveguide Barretter Mounts, 2.6 to 12.4 GC

Reflectometer Mounts—characterized by flat frequency response, low SWR, true square-law characteristics and high sensitivity, the broadband 485D Waveguide Barretter Mounts are supplied with factory selected barretters for maximum accuracy in reflectometer applications. hp S485D, 2.6 to 3.95 GC, $185.00; hp G485D, 3.95 to 5.85 GC, $170.00; hp J485D, 5.2 to 8.2 GC, $170.00.

General Purpose Mounts—hp S485A, 2.6 to 3.95 GC Fixed Tuned Barretter Mount, $165.00; hp 485B Tunable Detector Mounts, covering 3.95 to 12.4 GC, use either barretters for lowest SWR or silicon crystals for highest sensitivity. (Detectors not supplied.) hp G485B, 3.95 to 5.85 GC, $95.00; hp J485B, 5.85 to 8.2 GC, $90.00; hp H485B, 7.05 to 10 GC, $85.00; hp X485B, 8.2 to 12.4 GC, $75.00.

CRYSTAL
DETECTOR

hp 421A Waveguide Crystal Detector Mounts, 7.05 to 18.0 GC

Silicon diodes are employed in these mounts for better SWR characteristics at higher waveguide frequencies. Frequency response ± 2 db maximum over full range, square-law characteristic ± 1 db. Matched pairs are available for reflectometer applications. hp H421A, 7.05 to 10 GC, $95.00 each, $210.00 per matched pair; hp X421A, 8.2 to 12.4 GC, $75.00 each, $170.00 per matched pair; hp M421A, 10.0 to 15 GC, $125.00 each, $270.00 per matched pair; hp P421A, 12.4 to 18.0 GC, $130.00 each, $280.00 per matched pair.

hp 440A Detector Mount

For use in coaxial or waveguide systems, the hp 440A covers 2.4 to 12.4 GC. The mount uses either 1N21 or 1N23 silicon crystal, 1/100 amp instrument fuse or Sperry 821 barretter. (Detector element not furnished as part of instrument.) With the hp 442B Broad Band Probe (not shown), the 440A becomes a sensitive, easily tuned detector for slotted waveguide sections. hp 440A, $85.00; hp 442B, $40.00.

HEWLETT-PACKARD COMPANY
1064C Page Mill Road Palo Alto, California, U.S.A.
Cable "HEWPACK" DAvenport 6-7000
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Circle Reader Service Card 39

COAXIAL BROAD BAND FERRITE ISOLATORS

IN SIZES FOR EVERY APPLICATION

Now—from Kearfott, a new and broader line of Ferrite Isolators to satisfy the most exacting requirements of band width and isolation. Combining low unit loss characteristics with compactness and light weight, this new series of Kearfott Coaxial Isolators is available from present stock. Immediate selection and faster delivery is assured ...*precision performance proven.*

A FEW OF THE TYPICAL SPECIFICATIONS				
MODEL	FREQUENCY	ISOLATION	INSERTION LOSS	VSWR
C991100-402	1.2—2.6 KMC	10 DB Min.	1.0 DB Max.	1.20
C992100-405	2.0—2.5 KMC	30 DB Min.	.8 DB Max.	1.20
C992100-404	2.0—4.0 KMC	10 DB Min.	1.0 DB Max.	1.20
C992100-407	3.0—3.5 KMC	35 DB Min.	.8 DB Max.	1.20
C993100-401	4.0—8.0 KMC	10 DB Min.	1.0 DB Max.	1.20
C994100-403	7.0—9.0 KMC	25 DB Min.	.8 DB Max.	1.20

Complete information on these or all of the models is available by directing inquiries to: 14844 Oxnard Street, Van Nuys, California, or the sales office in your area.

GP

KEARFOTT DIVISION
GENERAL PRECISION, INC.

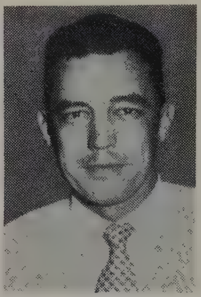
Little Falls, New Jersey

SALES OFFICES SEATTLE, WASH. VAN NUYS, CALIF. PHOENIX, ARIZ. DAYTON, OHIO CLIFTON, N.J.
PALO ALTO, CALIF. SAN DIEGO, CALIF. DALLAS, TEX. CHICAGO, ILL. WASHINGTON, D.C.

Circle Reader Service Card 40

(*Continued from page 50*)

PARKER SEAL APPOINTS MEYER VICE-PRESIDENT



Scott A. Rogers, Jr., President c Parker Seal Company, a Division of Parker-Hannifin Corp Culver City, Cal has announced th appointment of M George Meyer a Vice-Presiden Manufacturing the Company.

Mr. Meyer ha been Manager Manufacturing a the Company headquarters i Culver City and is responsible for all c Parker Seal's manufacturing facilities i Culver City and East Los Angeles, Cal fornia, and Berea and Lexington, Ken tucky.

To better serve the Company's interes from a manufacturing and productio standpoint, Mr. Meyer transferred hi headquarters to Berea, Kentucky abou February 1 and will continue his dutie as Vice-President-Manufacturing fror Kentucky.

Mr. Meyer joined Parker Seal in Janu ary, 1959, from Warner & Swasey, Inc Cleveland, Ohio, where he was associate for 12 years. He has announced that Jo Nenzell will continue as Manager c Western Manufacturing and Earl Hobei will continue as Manager of Eastern Manu facturing.

—*mwj*—

MIT SCHEDULES SUMMER SESSIO

A summer session on the problems c High Powered Radar System Design wi be held at Massachusetts Institute c Technology, Cambridge, Mass.

This two-week course is intended fo engineers engaged in the design of larg radar systems. A working knowledge c basic radar theory and techniques will b assumed.

The course will begin with theoretic discussion of a radar system as a com munication or measuring device. Relation ships among such quantities as accurac data rate, resolution, signal-to-noise rati and extent of measuring field will be ex amined primarily from the point of view of information theory. A more precis statement of the radar design problen will follow this theoretical introduction and will cover choice of frequency, powe level, antennas, and methods of modula tion and detection.

Special emphasis will be given to th signal design and signal detection problen related to detection and measurement i the presence of noise and clutter. Topi to be covered are pulsed signal processin signal coding, integrated signal proces ing systems, high-power transmitters, high power transmission line components, an multiple-element scanning arrays. Th

(*Continued on page 58*)

PROGRESS IN MICROWAVES

NEW X-BAND TUBES IMPROVE MICROWAVE RECEIVER PERFORMANCE

for Radar, Communications, ECM, Radiometry, Radio Astronomy Systems

The latest advances in G.E.'s continuing program for providing complete microwave coverage in a wide variety of tubes from L to K band are the traveling-wave tubes and voltage-tunable magnetron shown on the right.

OUTSTANDING LOW-NOISE, HIGH-GAIN PERFORMANCE

TWT types Z-3103 and Z-5259 are particularly suited for use in X-band receiver systems as broad-band amplifiers. The low-noise characteristics, ranging from 7 to 10 db max., coupled with a uniform high minimum gain of 25 db, make possible new levels of performance in detection and amplification of weak signals.

The low saturation power of both tubes protects mixers and other components from overload damage. Permanent magnet focusing eliminates need for additional power supply equipment in the circuit, including weighty, space-consuming solenoids.

Because of their inherent broad-band operation, the tubes require no tuning over their respective ranges, thereby permitting a significant degree of flexibility in frequency selection.

Compact and rugged, these metal-ceramic tubes are completely packaged with r-f and d-c connectors. The tubes illustrated withstand stringent specifications for shock (50 G's) and vibration (15 G's) in critical military applications.

VTM'S PROVIDE LINEAR TUNING

Newest addition to a growing line of G-E Voltage-tunable Magnetrons is the Z-5429. This tube's broad-band frequency range suits its use as a local oscillator in radar receiver circuits. A complete r-f power package, the tube gives a minimum of one milliwatt of linearly voltage-tuned power over the entire X-band range, without mechanical adjustment.

FREQUENCY RANGES AVAILABLE* TO DATE

Band	VTM (Kmc)	TWT (Kmc)
K	—	35.0–40.0 14.0–18.0
X	8.5–11.0	7.0–12.0
C	—	4.0–8.0
S	2.2–3.85	—
L	1.0–2.3	—

**This spectrum readily broadened and adapted for YOUR specific applications.*

TO ORDER, or to obtain more information, contact your nearest Power Tube sales office (telephone numbers listed below). 265-04-9545-8481-34

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GENERAL ELECTRIC

TELEPHONE TODAY—*Syracuse, OL 2-5102 . . . Clifton, N.J., GR 3-6387 . . . Washington, D.C., EX 3-3600 . . . Chicago, SP 7-1600 . . . Dayton, BA 3-7151 . . . Los Angeles, GR 9-7765.*

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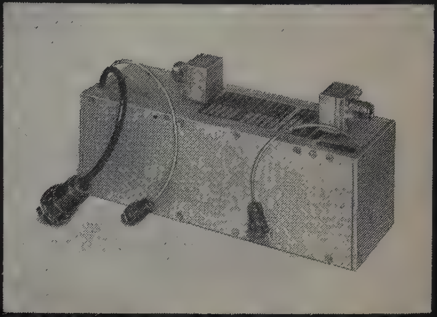
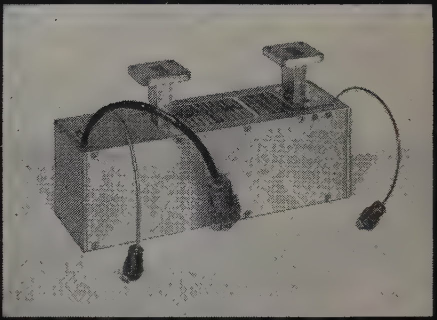
NEW TRAVELING-WAVE TUBES

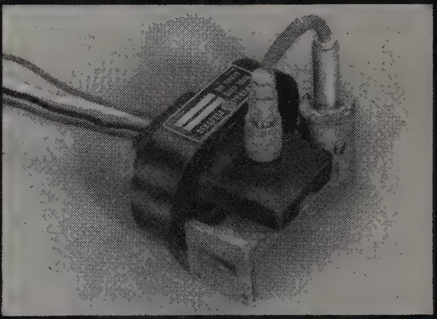


Z-3103 7.0-11.0 Kmc, 5 mw Output, 10 db Max. Noise Figure



Z-5259 8.0-12.0 Kmc, 5 mw Output, 10 db Max. Noise Figure

NEW VOLTAGE-TUNABLE MAGNETRON



Z-5429 8.5-11.0 Kmc, 1 mw Output (min.), 9.0 mc/v Tuning Rate

G-E POWER TUBE DEPARTMENT PRODUCTS ALSO INCLUDE:

- Ignitrons
- Hydrogen thyratrons
- Magnetrons
- Metal-ceramic tetrodes
- High-power duplexers
- High-power waveguide filters
- Klystrons
- Thermionic converters

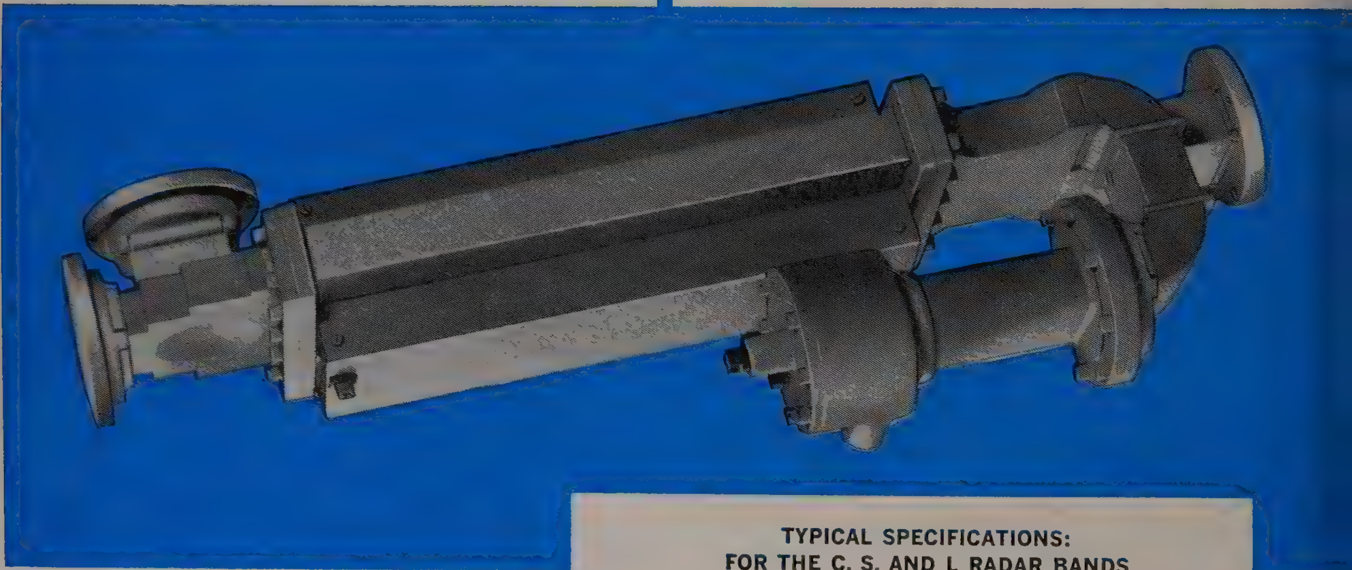
HIGH POWER FERRITE DUPLEXERS with WATER LOAD TERMINATIONS

● High power ferrite duplexers are now available with the new Sperry water loads to meet the most exacting high power system requirements and military specifications.

Sperry duplexers, available for operation in C, S, and L bands, reflect the Company's leadership in the manufacture of high-power solid state devices using Sperry-developed solid state materials. These duplexers readily meet every requirement consistent with their specifications.

The water load termination is one integral unit with a standard connecting flange and input and output ports having standard pipe fittings. It is small, compact and extremely rugged. Model E42C1 water load (shown here attached to duplexer D51C1) is only 6¾″ long, weighs 3 lbs. These water loads will also be available in the L and S Radar bands.

Write for complete information.



TYPICAL SPECIFICATIONS:
FOR THE C, S, AND L RADAR BANDS

MODEL	PEAK POWER	AVERAGE POWER	APPROXIMATE DIMENSIONS	APPROXIMATE WEIGHT
DUPLEXER				
D51C1*	5.0 Mw	5.0 kw	24″ x 8″ x 6″	25 lbs.
D51S1	5.0 Mw	10.0 kw	32″ x 13″ x 7″	75 lbs.
D51L1	10.0 Mw	15.0 kw	96″ x 20″ x 16″	470 lbs.
WATER LOAD				
E42C1*	3.0 Mw	4.5 kw	3¼″ Dia. x 6¾″	3 lbs.
E42S1	2.0 Mw	10.0 kw	4¾″ Dia. x 11½″	11 lbs.
E42L1	10.0 Mw	18.0 kw	9″ Dia. x 21″	25 lbs.

*Illustrated C Band ferrite duplexer and water load available as standard items.

SPERRY

SPERRY MICROWAVE ELECTRONICS COMPANY, *CLEARWATER, FLORIDA • DIVISION OF SPERRY RAND CORPORATION*

Microline Instruments • Radar Test Sets • Systems Instrumentation • Solid State Devices and Materials • ***Microwave Components and Antennas***

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“IMAGINATION IS MORE IMPORTANT THAN KNOWLEDGE”

Albert Einstein

There are some who might argue this point with Einstein. But this much is certain: Wherever new knowledge is sought, imagination lights the way. And surely, only imagination of rare quality could have led Einstein to formulate his principle of relativity.

Einstein applied the insight of imagination to basic science. But imagination can be just as powerful in the creation and application of technology. And nowhere, perhaps, is imagination challenged over so wide a range in both science and technology as in the problems of electrical communications.

At Bell Telephone Laboratories, scientists and engineers range far and deep in search of the answers. They probed deep into solid-state physics to discover the transistor principle, and they speculated and synthesized in an entirely different area of knowledge to create the giant microwave system that carries your TV programs across the country. They study ways to protect the giant molecules in plastic cable sheath, and they explore the basic information content of speech to devise better ways to transmit it. They devise ultrasensitive amplifiers to capture radio signals from distant places, while they conceive and develop new switching systems of unprecedented capabilities. Side by side with the development of transoceanic cable systems they are exploring the possibilities of world-wide communications via man-made satellites.

By exploring every pathway to improved electrical communications, they have helped make your Bell System communications the world's best and they will work to keep it so.

BELL TELEPHONE LABORATORIES
WORLD CENTER OF COMMUNICATIONS
RESEARCH AND DEVELOPMENT

SPECIAL *Motor-driven* ROTARY SWITCHES

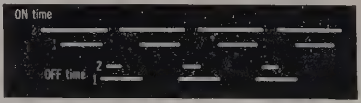
for

Telemetering
Sampling
Computers
Comparison systems
Remote controls
Multiplexing
Radar display

— in fact, wherever high-speed, precise multi-circuit switching in complex electric and electronic circuits is required.

Electro Switch designs and builds *to your performance specifications* — and to meet severe environments and MIL-spec requirements — special rotary switches that range from subminiature, dry-circuit selectors to heavy-duty, power-handling commutators.

Typical performance of special motor-driven rotary switch



3 poles; 30 positions per pole; non-shorting
Duty cycle: pole 1 — 78%; poles 2 & 3 — 53%
Life: more than 35,000,000 rotations at 1 ma 100 volts d-c
Insulation resistance: 100 megohms
Angular accuracy: ¼ degree
Designed to meet applicable MIL specifications

Write for our data form and check list to use in specifying special rotary switches.

ELECTRO SWITCH
SLIP-RING DIVISION
CORP.
Osterville, Massachusetts

Circle Reader Service Card 43

Industry News

(*Continued from page 54*)

special problems of very large antenna systems and radomes will be included.

Insofar as possible, lectures will stress fundamental processes rather than detailed design. The lectures will be concluded with the presentation of several case studies in the design of large radar systems for range instrumentation and surveillance of space.

The lectures will be given by staff members of the M.I.T. Lincoln Laboratory and of the Electrical Engineering Department assisted by guest lecturers who have made notable contributions to the field. The program will be under the direction of Mr. Jerome Freedman, Head of the Radar Division of Lincoln Laboratory.

Additional information on the courses can be secured from the Director of the Summer Session, Massachusetts Institute of Technology, Cambridge 39, Massachusetts.

— mwj —

FIFTH NATIONAL SYMPOSIUM ON GLOBAL COMMUNICATIONS BROADENS PROGRAM

Plans are being made for a broader technical program for the Fifth National Symposium on Global Communications held in Chicago, Ill., than was originally anticipated. Dr. W. L. Firestone, General Chairman, made this announcement as his Program Committee proceeded with the task of selecting and scheduling papers for the conference, which will be held May 22-24, at the Hotel Sherman.

He said that the response to the call for papers had exceeded all expectations, that the quality of the submitted papers was very high, and that the range of interests was wide. Topics vary from studies on the use of hitherto unexplored sectors of the electro-magnetic spectrum for signal propagation in outer space, to descriptions of the latest equipment for communication via radio, telephone, and telegraph facilities.

With the evidence of enthusiastic interest in communications on a global scope, Dr. Firestone stated that the estimate of probable attendance has been revised sharply upward. Larger meeting rooms will be utilized, and three simultaneous sessions of papers will be planned for each morning and afternoon during the conference, instead of two.

— mwj —

DYNATRONICS OPENS DIVISION IN VAN NUYS

Dynatronics, Inc., Orlando, Fla., has opened its Pacific division recently with Myron Roebuck as vice-president in charge of the western operation, according to Dynatronics president Parker Painter, Jr.

Roebuck, formerly vice-president in charge of special projects at Canoga Electronics Corporation, says full-scale operations, will begin within two weeks at the 11,000 square foot Van Nuys, Cal. facility.

(*Continued on page 62*)

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Remarkable in concept . . . the rigidly homogenous design of standard International Rectifier Silicon High Voltage Columns expands your design opportunities by providing rectifying capacity up to 1 kw per cubic inch of column . . . in ratings to 120,000 volts . . . current ratings to 50 amp. . . . in limitless proportions . . . with a total system reliability exceeding that of its MIL type component parts.

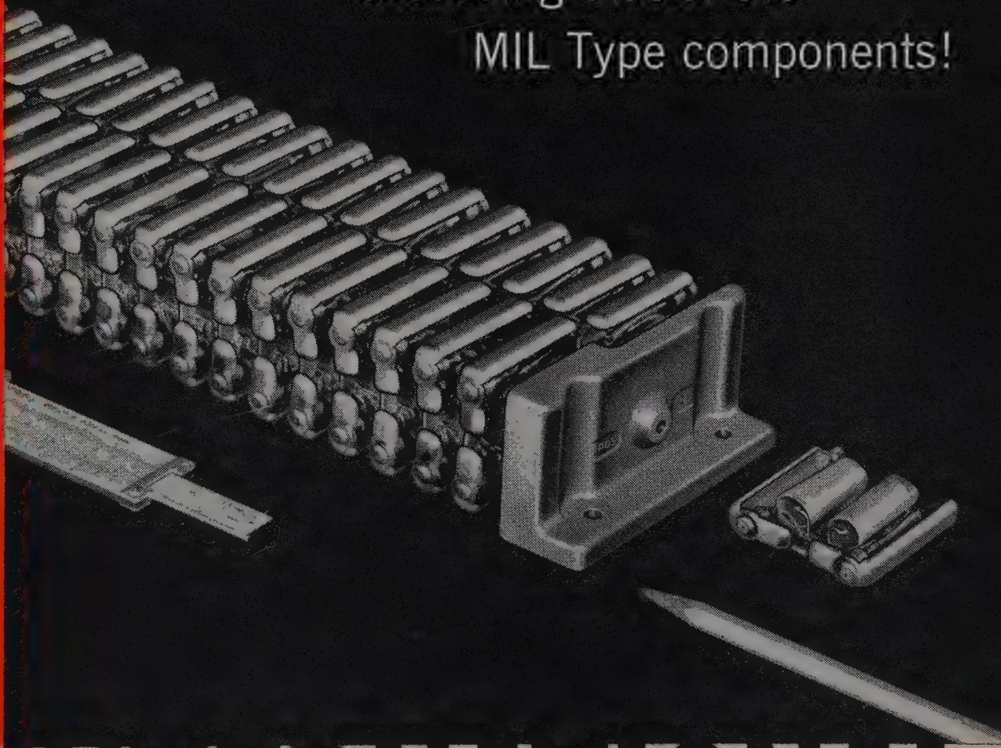
They were conceived to simplify circuitry, thus dramatically reduce the size and cost of equipment for long-range radar and television transmitters, induction heating, electrostatic precipitation, particle acceleration, pulse modulation, ultrasonic transducers, plasma research . . . wherever an ultra-stable high voltage-high current dc source is required.

They have done just that in countless applications!

They can do the same for you!

REMARKABLE!

Superpower High Voltage Rectifiers rated to **1 KW PER CUBIC INCH** . . . with a total system reliability exceeding that of the MIL Type components!



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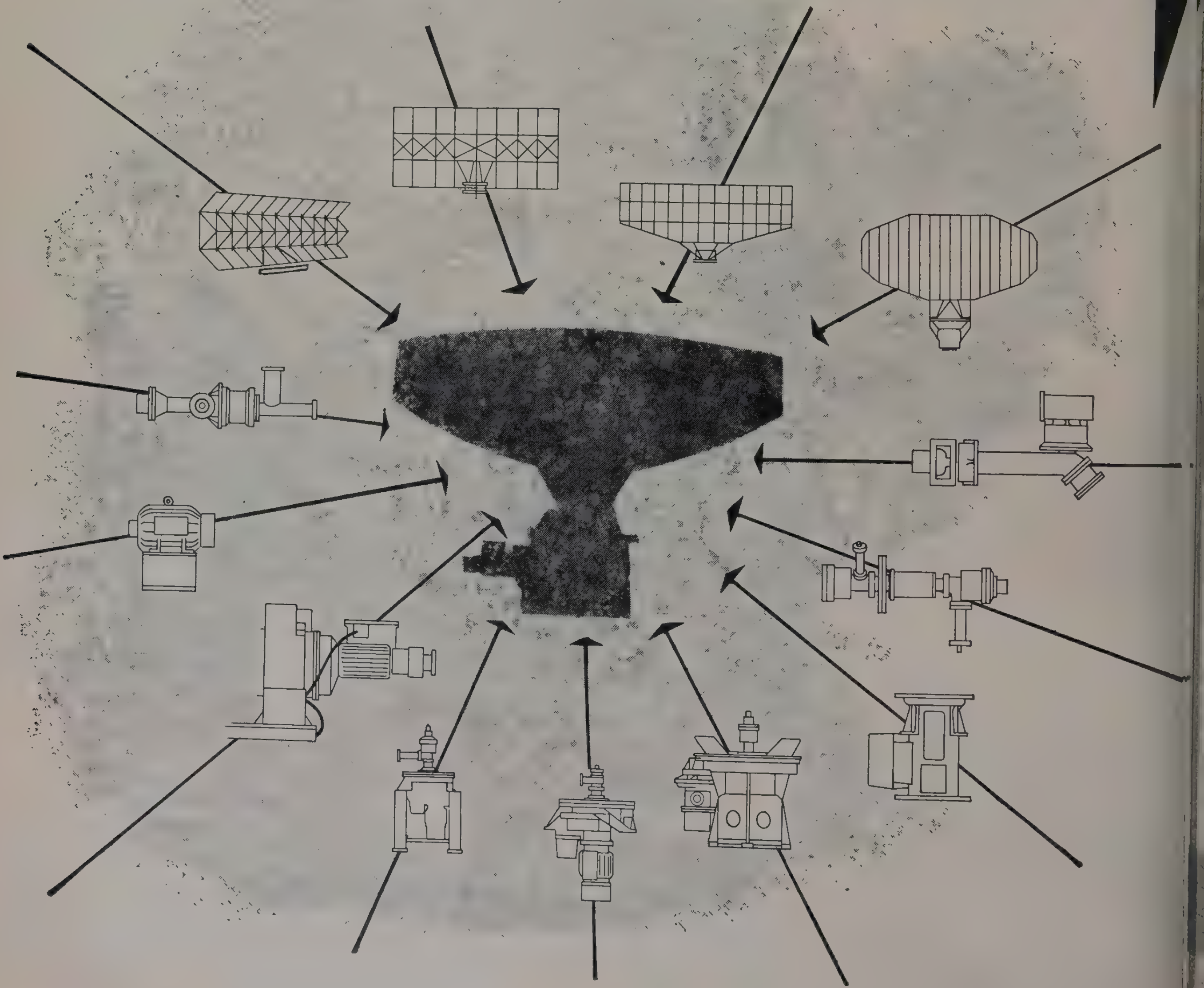
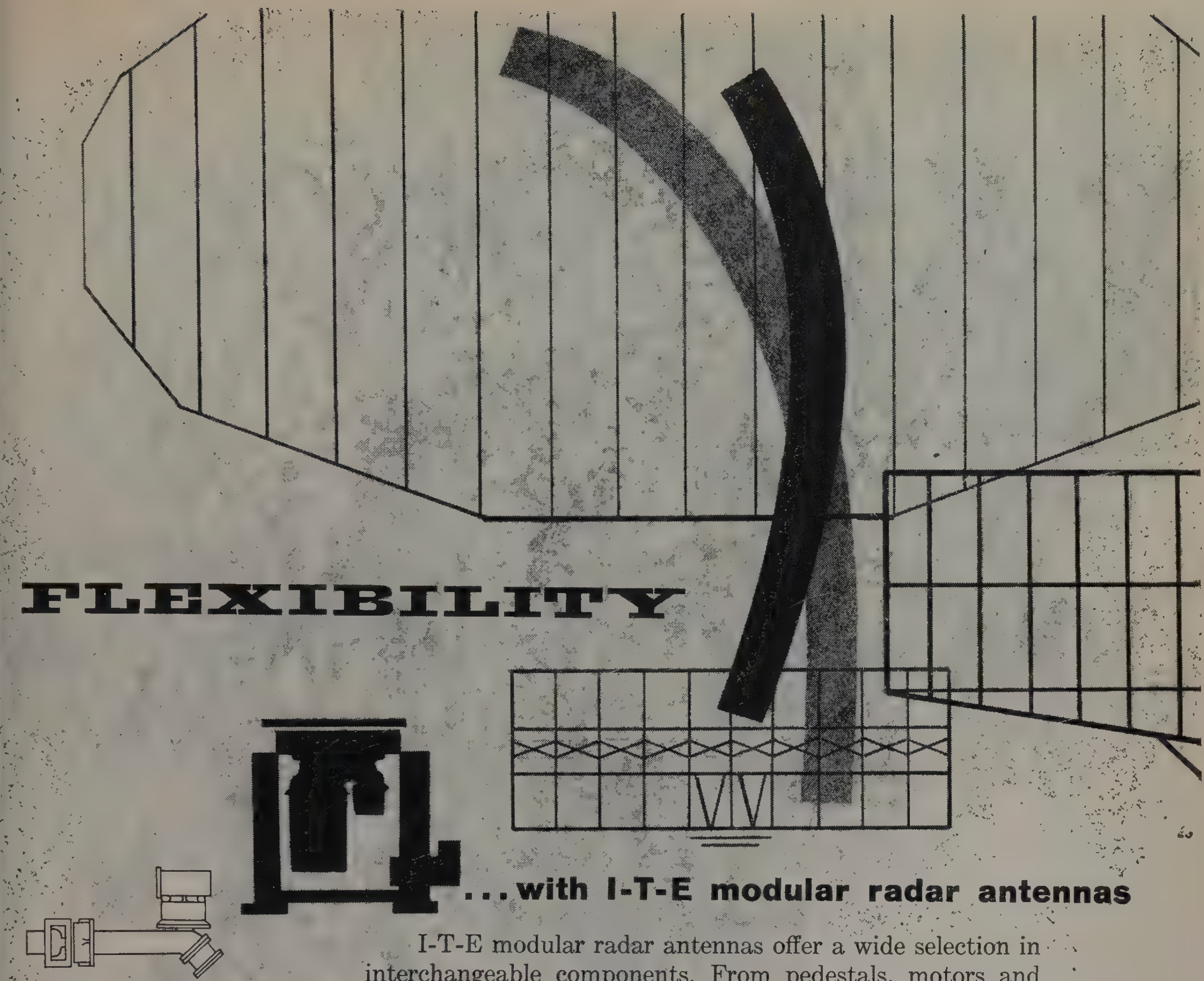
The **I-T-E Modular** design concept
applied to radar antenna systems
permits a wide latitude in the
choice of interchangeable antennas,
rotary joints, pedestals, drives
and associated component combinations.
all components have been field tested
and proved under every service condition.

One of the many advantages of the modular concept is . . .



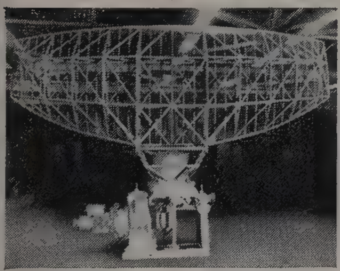


FLEXIBILITY

...with I-T-E modular radar antennas

I-T-E modular radar antennas offer a wide selection in interchangeable components. From pedestals, motors and controls to screens and reflectors, each component is designed to permit conversion with minimum effort.

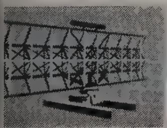
Rotary joints, as an example, are easily matched to antennas. They are standard in ranges from 200 Mc to 5,000 Mc and are replaceable by the removal of only four bolts. Unstabilized or stabilized bases are produced for this modular concept with a variety of azimuth and synchro drives, reduction gears and motors. Seldom will a combination of these components fail to meet most specifications and their dependability has been proven through years of service in the field under actual operating conditions.



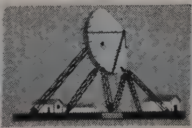
Investigating the limitless combinations possible with the I-T-E modular design concept might save you engineering costs and vital delivery time. Write to I-T-E Circuit Breaker Company, Special Products Division, Dept. MJ, 601 E. Erie Ave., Phila. 34, Pa. or call GArfield 6-5700.

I-T-E CIRCUIT BREAKER COMPANY

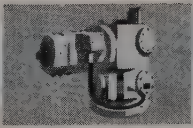
SPECIAL PRODUCTS DIVISION



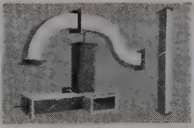
RADAR ANTENNA SYSTEMS



UHF ANTENNA SYSTEMS

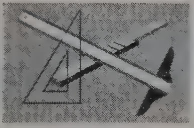


PEDESTALS DRIVES • CONTROLS

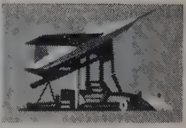


WAVEGUIDES & COMPONENTS

RESEARCH & DEVELOPMENT



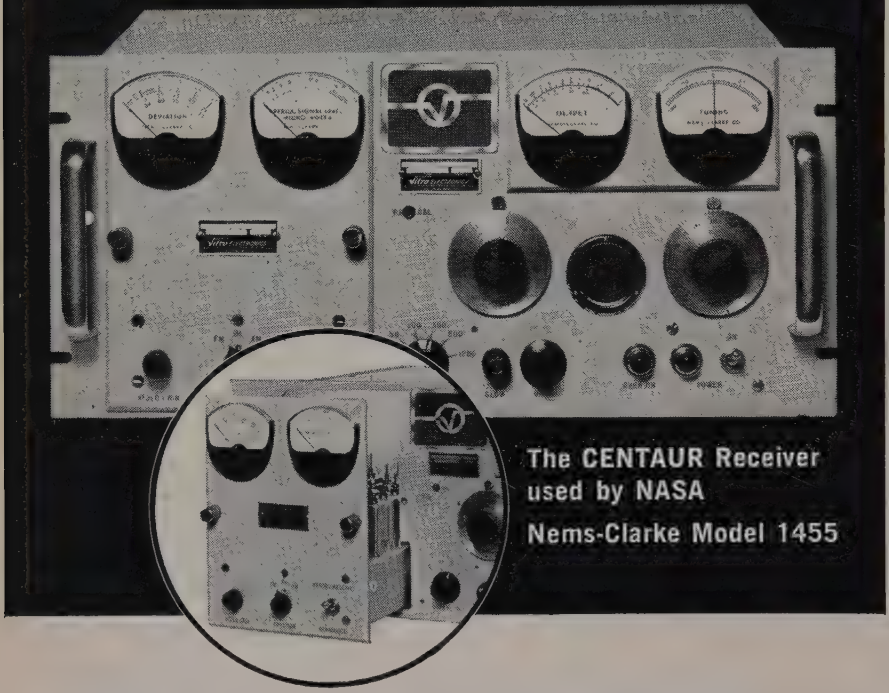
DESIGN & ENGINEERING



PRECISION MANUFACTURING

Circle Reader Service Card 45

MODULAR TELEMETRY RECEIVER FEATURES MULTIPLE BANDWIDTH SELECTION



The CENTAUR Receiver used by NASA
Nems-Clarke Model 1455

Designed to provide a selectable bandwidth capability for PCM, the 1455 most nearly approximates a "universal" telemetry receiver. IF/Demodulator Modules are available in bandwidths ranging from 100 KC to 1.5 MC. Each module contains 3 independent demodulators. Selectable by a front panel switch, they are: Foster-Seeley Discriminator, Phase-Lock Detector, and AM envelope detector. As a further refinement in signal-to-noise ratio enhancement, the video amplifier incorporates a video bandwidth filter having a 6 db per octave roll-off adjustable from 20 KC to 1.2 MC by means of a front panel switch. This receiver is capable of **optimum** reception of any known type of telemetry signal. Features: 5 MC pre-detection recording output, playback input terminals, and integral VFO, automatically actuated by a micro-switch on the crystal socket. The modulation sensitivity and deviation meter scales provide output voltages and meter deflections which are essentially the same percentage of bandwidth in all modules.

Available as an accessory unit is the Nems-Clarke IFC 1400 Pre-Detection Converter which permits use of the 1455 with stationary-head instrumentation tape recorders for pre-detection recording.

See the 1455 Receiver at the I.R.E. Show, Booths 3917-3919.

Vitro ELECTRONICS A DIVISION OF VITRO CORPORATION OF AMERICA
PRODUCERS OF NEMS-CLARKE EQUIPMENT
919 JESUP-BLAIR DRIVE, SILVER SPRING, MARYLAND / 2301 PONTIUS AVENUE, LOS ANGELES 64, CALIFORNIA

Circle Reader Service Card 46

Industry News

(*Continued from page 58*)

Dynatronics, founded in 1957, is involved in range and airborne measuremen and instrumentation equipment associate with the missile and space age field at it 42,000 square foot Orlando plant. The firm's goal for 1961 is $5 million.

The Van Nuys operation is designed t complement Florida activities and giv Dynatronics easier access and communic tion with its West Coast customers Painte said.

"Without question, the Pacific Division will develop in other areas of electroni research and development to meet the specific needs expressed by Southern California military installations and defens firms," Painter explained.

— *mwj* —

ELECTRO-TEC NAMES ENDRES TO MARKETING STAFF

William Endres has joined Electro-Tec Corp., South Hackensack, N. J., as marketing staff assistant in public relations, it has been announced by George E. Tubb, director of marketing. Electro-Tec is a manufacturer of relays, slip rings and related precision electronic equipment for industry and the military.

Endres comes to his new post from General Bronze Corp., where he was in the public relations department of the marketing division. He was previously with the Mobil Co. as a sales engineer.

Endres, a graduate of Syracuse University, school of business administration, also attended Lehigh University, school o engineering. He is a member of Alpha Kappa Psi.

— *mwj* —

FANK NAMED MANAGER AT GE PLANT

Dr. F. Beringer Fank has been named manager, Low Power Traveling Wave Tube Engineering at General Electric's electronics plant at Palo Alto, Cal.

The appointment was announced by S E. Webber, manager, Engineering for the Palo Alto operation, a separate produc section of the Company's Power Tube Department.

Dr. Fank, a native of Glendale, Cal., assumes the position formerly held by Dr C. G. Lob, who was recently named manager of the new product section, formed in a reorganization of the Company's Microwave Laboratory.

Dr. Fank joined General Electric in 1951 and is a graduate of the Company's Engineering Training Program. He was

(*Continued on page 66*)

Circle Reader Service Card 47

COPPER CLAD
REXOLITE®
2200

for
STRIP LINES
DIRECTIONAL COUPLERS
DUPLEXERS
SLOT ARRAYS

features:
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Low Dielectric Constant
Extreme Dimensional Stability
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MENLO PARK ENGINEERING
MENLO PARK, CALIFORNIA

More complete frequency coverage with this new line of

Electronically Swept Oscillators

0.5 to 18.0 KMC

The Menlo Park Engineering Electronically Swept Microwave Oscillators provide a fast, convenient method for determining wide band frequency response of microwave devices and systems. When used with reflectometers, previously tedious VSWR measurements are reduced to a few seconds. Transmission characteristics of filters, attenuators, ferrite devices and amplifiers may be measured directly and recorded on mechanical recorders for a permanent record.

SPECIFICATIONS:

Sweep Mode: Recurrent, 0.5 to 100 cps; manually triggered, 0.01 to 0.5 cps; continuously variable. Change of carrier frequency is downward from frequency dial setting and linear with respect to time.

CW Mode: Output frequency is read directly from calibrated frequency dial. Calibration accuracy ±1% of reading.

Sweep Output: A +25V sawtooth time coincident with RF sweep.

Deviation Control: Continuous control of sweep width allows sweeping of all or any part of RF bandwidth. Direct reading meter displays sweep width in megacycles to an accuracy of ±3%.

Modulation: Amplitude, pulse, frequency, internal square wave.

Power: 115 VAC 60 cycle approximately 900 watts

Dimensions: 23″ wide, 16¾″ high, 21¾″ deep.

Model	Frequency Range	Output Power	Output Connector
400	0.5 to 1.1 Kmc	50 mw (min)	Type N
410	1.0 to 2.0 Kmc	50 mw (min)	Type N
420	2.0 to 4.0 Kmc	10 mw (min)	Type N
430	4.0 to 8.0 Kmc	10 mw (min)	Type N
440	6.5 to 11.5 Kmc	10 mw (min)	Type N
450	8.2 to 12.4 Kmc	10 mw (min)	Type N or Waveguide UG-135/u
460	12.4 to 18.0 Kmc	10 mw (min)	Waveguide UG-419/u

Sales Representatives in principal cities

MENLO PARK ENGINEERING

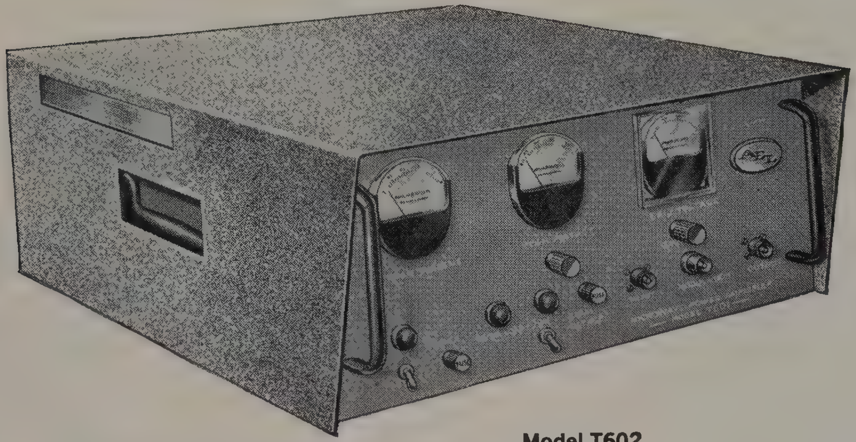
711 Hamilton Avenue, Menlo Park, California DAvenport 6-9080 TWX Pal Al 110

NEW!

MICROWAVE POWER AMPLIFIERS

2 kmc–20 kmc IN ONLY 2

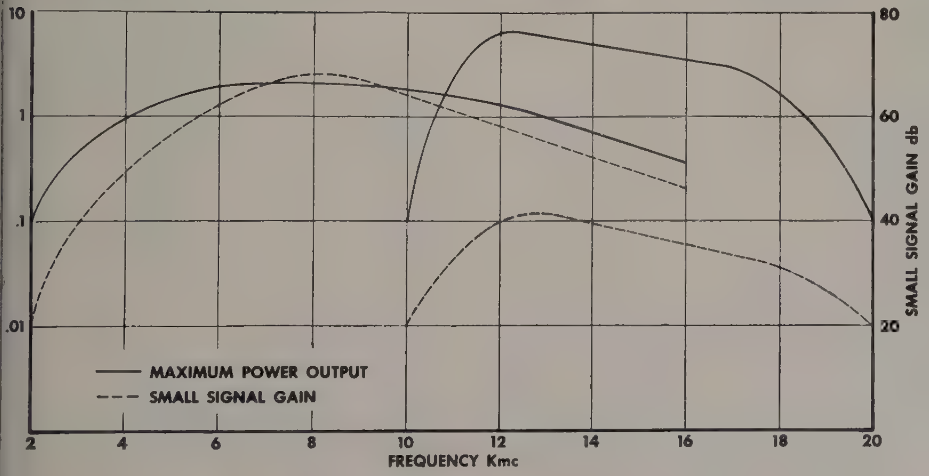
TWT AMPLIFIERS



Model T601
2-15 kmc

TYPICAL CHARACTERISTICS

Model T602
10-20 kmc



Product Features:

- Rugged construction
- Completely self-contained
- Provision for modulation
- Adjustable gain control
- Regulated power supplies
- Supplied in attractive bench cabinet or can be mounted on standard 19" rack

Typical Applications:

- Converts low level signal generators to high power sources
- Efficient harmonic generator
- Antenna pattern measurement source
- Converts to high power oscillator with appropriate adapter

Accessory Equipment Available

For complete technical data call or write:
Amer. Elect. Labs., Inc.
121 North 7th Street, Philadelphia 6, Pa.
Phone: WAlnut 5-8780

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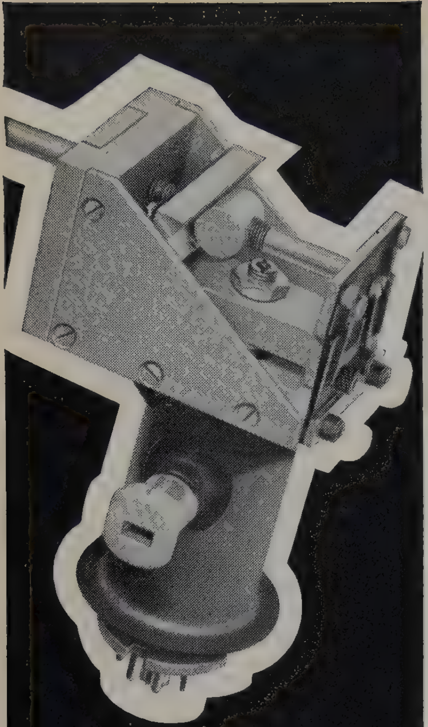

E.M.I.

Q-BAND REFLEX KLYSTRONS

Five high voltage, integral cavity types, with improved plate tuner for good frequency stability and freedom from microphony.

Type No.	Approx. f range KMc/s	Min. Power (mW)	I_A (mA) (at V_A=2KV)
R9521	35–40	15	12
R5146	34.2–35.6	30	10
R9546	32–38	15	12
R9518	28–32	15	12
R9547	24–28	15	12

Average electronic tuning range of above, 60 Mc/s; WG22 waveguide termination.

...AND A NEW K-BAND KLYSTRON:

with similar external dimensions and tuner to R9546:

R9602 22–26 15

Average electronic tuning range, 40 Mc/s; WG20 waveguide termination.

The extensive range of EMI special tubes includes: plug-in klystrons & cavities, photomultipliers, camera & C.R. tubes.

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Industry News

(Continued from page 62)

with the Company's Electronics Laboratory in Syracuse for two years before joining the Microwave Laboratory here in 1954.

Dr. Fank is a graduate of Stanford University, and received his doctor's degree in electrical engineering there in 1958. He is a member of the Institute of Radio Engineers and Sigma Xi.

—mwj—

1961 WESCON DATES LISTED

The dates for the 1961 WESCON, to be held at the Cow Palace, San Francisco, Cal., are August 22 through August 25.

The show and main technical program will be at the Cow Palace, with some special evening sessions and related activities to be situated in downtown locations. There has been no designation of a headquarters hotel to date.

Information regarding exhibits is available through Don Larson, WESCON Manager, 1435 S. La Cienega Blvd., Los Angeles 35, Cal.

—mwj—

PICKARD & BURNS PLANS R&D LAB

Construction of a modern 60,000 foot Research and Development Laboratory is planned for Pickard & Burns, Inc., Electronics subsidiary of Gorham Manufacturing Co., Providence, R. I.

Mr. Harold S. Burns, President of Pickard & Burns, Inc. and Vice President, Electronics of Gorham Manufacturing Company announced that occupancy is scheduled for Fall, 1961.

The laboratory will occupy six acres of land in the Waltham Research and Development Park on Massachusetts' Route 128, the center of New England's thriving Electronics Industry.

Mr. Burns stated that separate facilities in Needham will be consolidated in the new Waltham Laboratory to enable Pickard & Burns to expand its research and development capabilities in the fields of communication, navigation, and electronics systems.

One feature of the Waltham structure will be a Microwave Tower which will permit the investigation and evaluation of microwave and other antenna devices.

—mwj—

GEORGIEV JOINS LENKURT

Peter Georgiev has joined Lenkurt Electric Co., Inc., San Carlos, Cal., as a senior electrical engineer in the Advanced Development Group, where he has been assigned to studies of new microwave applications in telecommunications.

He previously was with General Electric Co. at Lynchburg, Va., as a microwave development engineer.

Georgiev is native of Bulgaria. He received his degree in electrical engineering from the University of Sofia, and was a development engineer for Elprom, Inc., there from 1953 until 1957.

He is a member of the Institute of Radio Engineers

—mwj—

GUNTHER NAMED REL PRESIDENT

Election of Frank A. Gunther as President of Radio Engineering Laboratories, Inc., (REL), Long Island, N. Y., communications subsidiary of Dynamics Corp. of America, has been announced by DCA. Mr. Gunther had been Executive Vice President and General Manager of REL since July, 1959.

A 35-year veteran with REL, Mr. Gunther joined the Company in 1925, became a vice president in 1929 and has served in virtually every department and capacity. A pioneer in advanced communications engineering, he was instrumental in development of the world's first two-way mobile radio, very high frequency two-way aircraft installation, vhf radio-teletype, FM broadcast equipment, mass-produced FM receivers for professional use, Loran transmitters, and, in recent years, tropospheric scatter equipment.

A contributor to many technical publications, he is a Senior Member of the

(Continued on page 68)

AL'S ALLEY

Like anybody who is anybody in the antenna field, Al Fowler of ANTENNA SYSTEMS, INC. will be exhibiting at the show this year. Booth 2009. Second floor. South Room. That's Al's Alley and where Al is, you'll find Charlie Creaser and Bill VanderWolk ... plus the latest information on the latest developments in the antenna field.

BOOTH 2009. See you there.

ANTENNA SYSTEMS INC.

HINGHAM, MASSACHUSETTS

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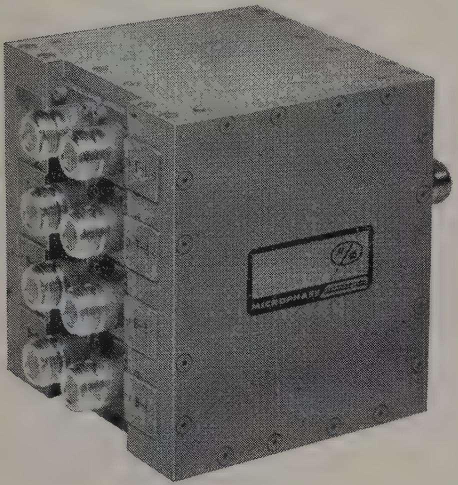
MC Multiplexers



MICROPHASE PART NUMBER MP-C218-1

L-Band Octaplexer, interconnecting four transmitters and four beacons to one common antenna. Transmitter and beacon channels are interlaced over a frequency range of 200 mc.

The unit is 4½" x 4½" x 5", and is built to withstand shock and vibration encountered in satellite launch and orbit.

SPECIFICATIONS

Transmitter Channels

Insertion Loss	1.5 db max
Passband Flatness over 10-mc Bandwidth	±0.1 db
VSWR (both input and output terminals)	1.5 max

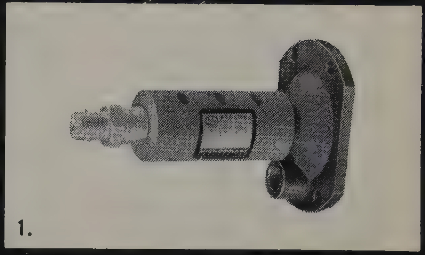
Beacon Channels

Insertion Loss	3.0 db max
VSWR (both input and ouput terminals)	1.5 max

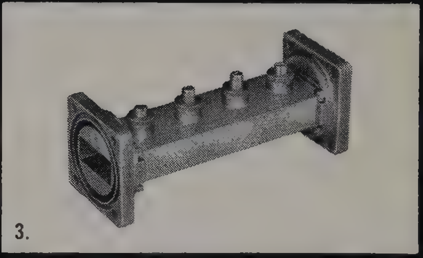
Isolation Characteristics

Transmitter to Transmitter	50 db min
Beacon to Beacon	60 db min
Transmitter to Beacon	60 db min
Beacon to Transmitter	20 db min

OTHER MICROPHASE COMPONENTS


1.

2.


3.

1. **Filter Detector, High-Pass—Model CVF3810—**Designed to mount on the antenna of a direct-detection receiver (shown with antenna). It provides 70 db attenuation from DC to 3 kmc, and passes 4 to 10.5 kmc with an overall sensitivity of —50 dbm average (—45 dbm min). The unit has internal DC return. Overall length, without antenna, is 3¼".
2. **High-Pass Filter—Model C900-1**—has 0.5 db insertion loss in its passband (225-550 mc). It provides 50 db minimum attenuation from 0.67 f_c down to DC. Light weight and rugged, the filter is designed to meet military environmental specifications. The overall length of the unit, excluding connectors, is 3⅝ inches.
3. **X-Band Waveguide Preselector—Model WG112-4P** —is tunable. The unit has 50 mc 3 db band width and 300 mc 60 db band width. The preselector has less than 1 db insertion loss and 1.4 VSWR. It is 5 inches long and is provided with UG-52A/U flanges.

MICROPHASE
CORPORATION

x 1166W Greenwich, Conn. NO 1-6200 WE 9-9190 TWX GNWICH CONN 759

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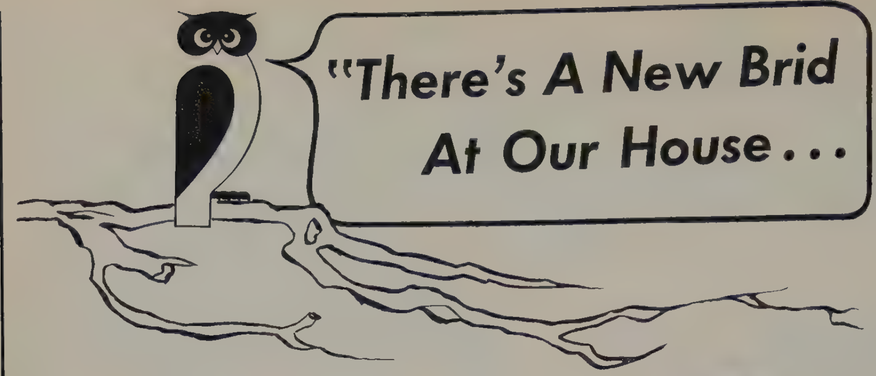

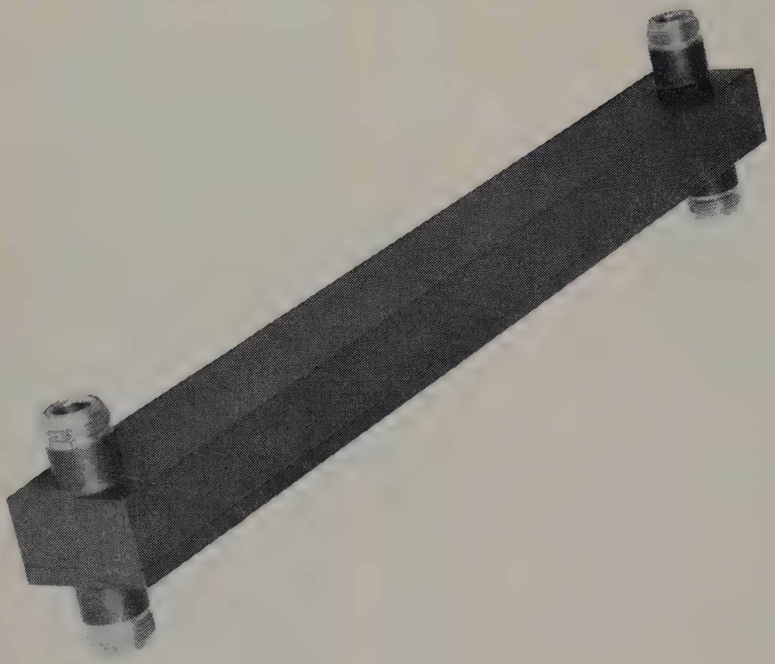

. . . To whit, Model 748 Temline Hybrid"

FREQUENCY RANGE:	60 MC TO 125 MC
COUPLING:	3 DB ± 0.5 DB
DIRECTIVITY:	30 DB MINIMUM
VSWR:	1.15 MAXIMUM
INSERTION LOSS:	0.1 DB MAXIMUM
CONNECTORS:	FEMALE TYPE N
BODY DIMENSIONS:	7/8" × 1 3/8" × 22 11/16"
WEIGHT:	6 LB, FABRICATED IN BRASS
PRICE:	$225.00

Alternate connectors supplied on request. Mounting provisions can be incorporated to comply with specific requirements.

The complete series of SAGE TEMLINE Hybrids covers the 60 mc to 4000 mc spectrum in octave band steps. Special units with wider, narrower, or higher frequency ranges can be furnished to customer specifications.

SAGE LABORATORIES, INC.
3 Huron Drive • East Natick Industrial Park • Natick, Massachusetts

Industry News

(*Continued from page 66*)

Institute of Radio Engineers, Fellow and Past President of the Radio Club of America, Vice President of the New York Chapter of the Armed Forces Communications Associations, Honorary Director of the Single Sideband Amateur Association and member of the Veteran's Wireless Operator's Association and of the Quarter Century Wireless Association.

—*mwj*—

MORTENSON HEADS SOLID-STATE DEVICES GROUP

Microwave Associates, Inc., Burlington, Mass., announces the appointment of Dr. Kenneth Mortenson to head a research group working on Active Solid-State Microwave Devices. In this newly created position, Dr. Mortenson will direct research and development activities on new microwave solid-state semiconductor tunnel-diode oscillators, and other solid-state amplifiers. He will report directly to Dr. Lawrence Gould, Vice President and Manager of the Electron Tube and Device Division.

Dr. Mortenson previously was a research physicist with the General Electric Co. Research Laboratory at Schenectady, N. Y. He was also Associate Professor at the Electrical Engineering Department of Rensselaer Polytechnic Institute and Consultant to the RPI Radio Astronomy Observatory.

He received his BS and BEE degrees from Rensselaer Polytechnic Institute in 1947 and 1948 respectively. He received his Masters degree in Electrical Engineering in 1950 and his PhD in Applied Physics in 1954, both from RPI.

He is a member of Eta Kappa Nu and Sigma Xi and is also a member of three professional groups of the Institute of Radio Engineers.

—*mwj*—

CONFERENCE TO BE HELD IN MAY

The National Telemetering Conference will be held May 22-24 at the Sheraton Towers Hotel, Chicago, Illinois.

Conference theme will be "Science and Education in Telemetry."

The Conference is sponsored jointly by five technical sciences: American Institute of Electrical Engineers; American Rocket Society; Institute of Radio Engineers; Institute of the Aerospace Sciences; and Instrument Society of America.

—*mwj*—

(*Continued on page 70*)

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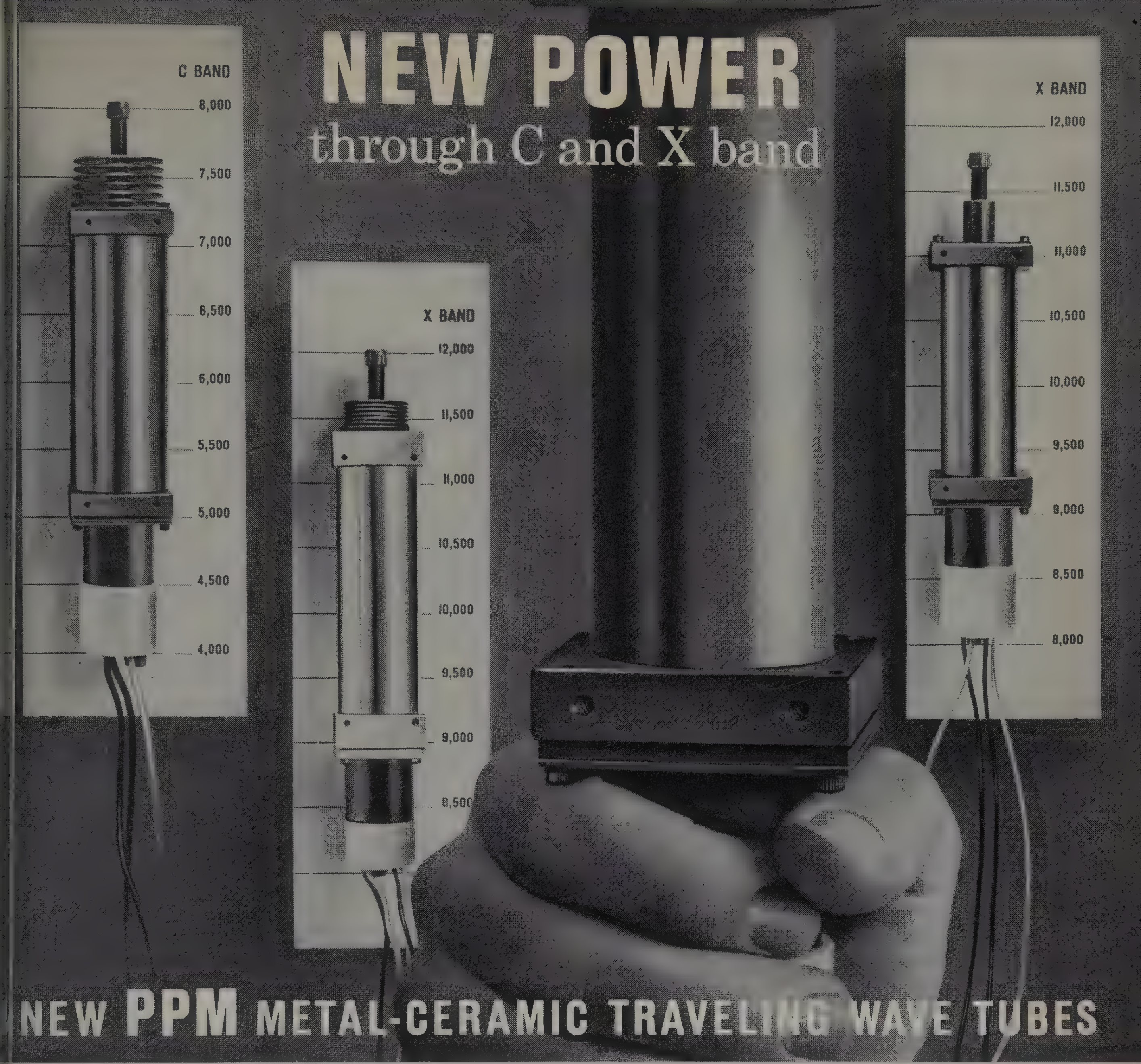
NEW POWER
through C and X band
C BAND
8,000
7,500
7,000
6,500
6,000
5,500
5,000
4,500
4,000
X BAND
12,000
11,500
11,000
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9,000
8,500
X BAND
12,000
11,500
11,000
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8,500
8,000
NEW PPM METAL-CERAMIC TRAVELING WAVE TUBES

Climaxing ITT's long history of pioneering in the traveling wave tube field are these new PPM types covering C and X bands and distinguished by the highest power output over the greatest bandwidths thus far available. The X-band TWT Type X-354 is rated at 5 watts CW from 8 to 12 kilomegacycles; the C-band TWT Type X-370 is rated at 10 watts CW from 4 to 8 kilomegacycles. Type X-368 serves as a driver for the X-354. As in other ITT traveling wave tubes, construction is exclusively metal and ceramic.

Power output and frequency coverage of this caliber result in a new standard of performance. For ECM requirements, frequency diversity radar or any other broadband microwave application, ITT has a complete line of S-band, C-band and X-band TWTs rated from .050 to 10 watts CW and to 1 kilowatt pulse output. ITT traveling wave tubes are available for immediate delivery and are backed by the world-wide resources and facilities of the ITT System.

Write for information on the complete line of ITT traveling wave tubes. Application assistance is available for your specific requirements.

ELECTRON TUBE DEPARTMENT ■ COMPONENTS DIVISION
INTERNATIONAL TELEPHONE AND TELEGRAPH CORPORATION, CLIFTON, NEW JERSEY

ITT COMPONENTS DIVISION PRODUCTS: POWER TUBES • IATRON STORAGE TUBES • HYDROGEN THYRATRONS • TRAVELING WAVE TUBES • SELENIUM RECTIFIERS • SILICON DIODES AND RECTIFIERS • TANTALUM CAPACITORS

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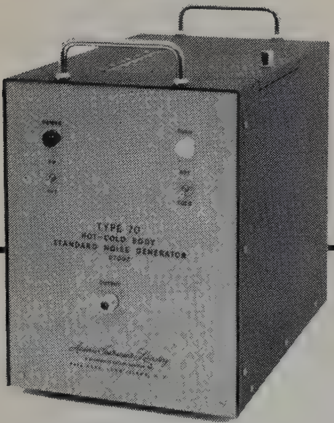


MEASURE
NOISE FIGURE
with
±0.08 db
ACCURACY

Extremely accurate measurement of low noise figures is provided by the AIL Type 70 HOT-COLD BODY STANDARD NOISE GENERATOR.

Utilizes two precision matched resistive elements, one immersed in liquid nitrogen and one contained in a temperature controlled oven, to provide accurate temperature references for noise figure measurement of

PARAMETRIC AMPLIFIERS
MASERS
LOW NOISE PREAMPLIFIERS

Frequency Range .....0 to 2000 mc
Relative excess noise output ... 6.83 db
Referred to 77.3°K
Accuracy ... ±0.08 db
Output Impedance ... 50 ohms
VSWR ... 1.15 maximum

Price $675

For full information write:

AIRBORNE INSTRUMENTS LABORATORY
DEER PARK, LONG ISLAND, N. Y.
A DIVISION OF CUTLER-HAMMER, INC.

(*Continued from page 68*)

BEAN WILL DIRECT SYSTEMS PROGRAMS

The appointment of Richard B. Bean as a program manager of the Systems Engineering and Management Operation (SEMO) of Sylvania Electronic Systems, a division of Sylvania Electric Products Inc., Needham, Mass. has been announced by Richard W. Couch, Manager of SEMO.

In his new capacity, Mr. Bean will be responsible for direction of numerous major systems programs now being carried on by Sylvania for the government. SEMO is responsible for obtaining, system engineering, and managing all large military systems contracts for Sylvania, and other GT&E subsidiaries.

Previously, Mr. Bean was affiliated with Automatic Electric Company, Northlake, Ill., another GT&E subsidiary, as director of special defense projects. During his fourteen years with Automatic Electric, Mr. Bean served as deputy to the chief executive of the management group, staff assistant to the president, and manager of administrative services.

—mwj—

MICROWAVE COMPANY ADDS TO STAFF

MCS Corp., Temple City, Cal., has announced an expansion of its technical and production management staff. Four department heads have been added, according to Louis Della Penna, president of the company. All the new staff members were formerly with DeMornay-Bonardi, Pasadena, Cal., in similar capacities.

Albert Coverly, appointed production manager of MCS, was formerly with DeMornay-Bonardi for six years, recently as works manager. Before that he was with the Hills Aircraft Co. in Manchester, England, for 15 years, as a master tool and die maker.

Eugene R. Draper, new chief engineer, was previously assistant chief engineer for DeMornay-Bonardi for 10 years, and prior to that was a project engineer for Hughes Aircraft for five years. Mr. Draper holds an ME degree from U.C.L.A.

Arthur W. Kermode is head of the microwave laboratory at MCS. He was formerly in charge of the DeMornay-Bonardi calibration laboratory for five years. Mr. Kermode attended California Polytechnic Institute, where he studied microwave technology.

Robert Wilfred Armiger is shop superintendent. His background includes six years at DeMornay-Bonardi, recently as shop foreman, and five years at Vickers Electrical Company, England, as tool room foreman. Mr. Armiger served his apprenticeship as a tool and die maker at the Ford Motor Co. of England for seven years.

—mwj—

P.I.B. SYMPOSIUM DUE ON ELECTROMAGNETICS AND FLUID DYNAMICS OF GASEOUS PLASMA

The eleventh international symposium organized by the Polytechnic Institute o Brooklyn will be held on April 4, 5 and 6, 1961 in the Auditorium of the Engineering Societies Building (33 W. 39 St., New York City).

This year the symposium has been organized by the Department of Aerospace Engineering and the Microwave Research Institute in cooperation with the Professional Groups on Electron Devices, Microwave Theory and Techniques and on Nuclear Science of the Institute of Radio Engineers and the Institute of the Aerospace Sciences. The support of the Air Force Office of Scientific Research, the Office of Naval Research and the U. S. Army Signal Corps permits this series to be held without any charge for admission or registration.

—mwj—

HANCE WILL PLAN RESEARCH FOR LOCKHEED

Dr. Harold V. Hance, has joined the Systems Research Center of Lockheed Electronics Company, Bedminster, N. J. He will serve as both Associate Director of the Center and as a Senior Scientist.

In his scientific capacity, Dr Hance will be concerned initially with defining problem areas for investigation, and with planning theoretical and experimental research in preparation for the development of new concepts, theories, and processes. Some of the areas with which he will be involved are pattern recognition, information retrieval, and cognitive systems, as well as problems of a more specialized nature in the field of signal processing.

Before joining Lockheed Electronics, Dr. Hance worked in various capacities for nine years at Hughes Aircraft Company in Culver City, California. The last position he held at Hughes was Senior Scientist in the Research and Development Laboratories.

Dr. Hance received the Bachelor of Science degree in electrical engineering from the California Institute of Technology. He took graduate work in radio and electronics at Stanford University, and received the Doctor of Science degree in electrical engineering from the Massachusetts Institute of Technology.

—mwj—

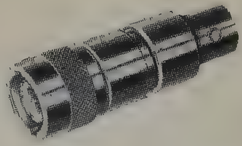
(*Continued on page 72*)

10,523 STANDARD COAXIAL COMPONENTS "ON THE SHELF"

IMMEDIATE DELIVERY FROM STOCK!

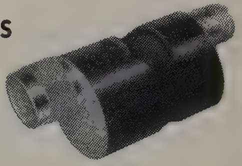
FIXED ATTENUATORS

DC to 12,000 mc
0 to 80 db
1.2 max. VSWR
2, 5, and 15 watts



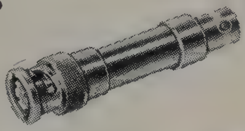
VARIABLE ATTENUATORS

DC to 10,000 mc
0 to 60 db
1.25 max. VSWR
Continuous or Turret



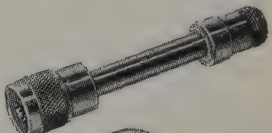
LOW PASS FILTERS

100 to 10,000 mc
1.3 max. VSWR
10 and 500 watts
Sharp cut-off.



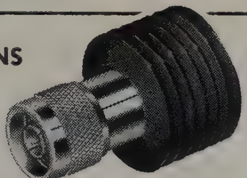
HIGH PASS FILTERS

200 to 6,000 mc
1.8 max. VSWR
10 and 50 watts
Sharp cut-off



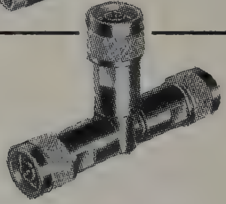
COAXIAL TERMINATIONS

DC to 13,000 mc
1.1 max VSWR
2, 10, 150 watts
Fixed and Sliding



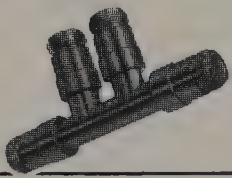
POWER DIVIDERS

DC to 10,000 mc
2 to 6 outputs
Resistive — wide band
Reactive — min. loss



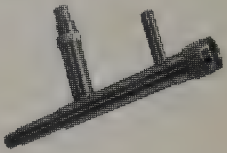
DIRECTIONAL COUPLERS

200 to 4,000 mc
Full octave Bandwidth
High directivity
Uni-bidirectional



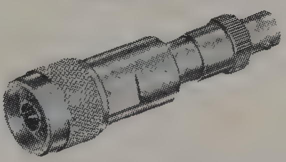
CRYSTAL MIXERS

250 to 8,000 mc
Single ended or balanced
1.5 max. VSWR
Adjustable L.O. Injection



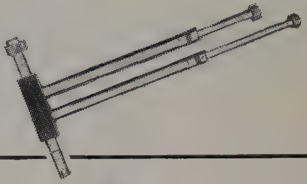
CRYSTAL MOUNTS

DC to 13,000 mc
Untuned, fixed tuned;
Padded; Tripolar
High Sensitivity



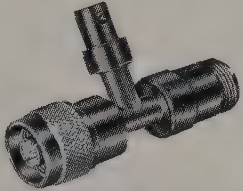
TUNERS

Stub Stretchers
Line Stretchers
Double Slug
Single, double, triple stub



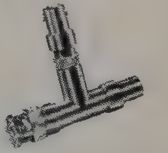
MONITOR TEES

Used to separate DC or video currents from an RF signal. Indispensable for monitoring helix intercept current in traveling wave tubes.



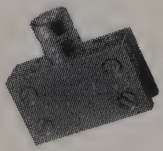
SIGNAL SAMPLERS

Used to monitor signals present in coaxial systems. Permits small signal to be taken from system without adding discontinuity. Coupling continuously adjustable.



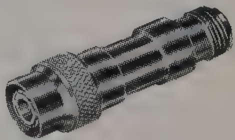
PRINTED CIRCUIT CONNECTORS

Side, end launchers
N, C, BNC, TNC
Screw-on or flange mounts.



DC BLOCKS/SHORTS

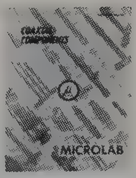
Sections of constant impedance transmission line with built-in blocking capacitor or DC by-pass.



- **All MICROLAB products are available FROM STOCK with Type N, C, HN, BNC or TNC male or female connectors.**
- **Special values, connector combinations and other special design features at same low cost and quick delivery.**
- **Prototype or production quantities at lowest cost.**

NEW CATALOG AVAILABLE

A new 72 page catalog listing thousands of stock coaxial components and product application information is now available from MICROLAB. Write on company letterhead for CATALOG NO. 10.



MICROLAB

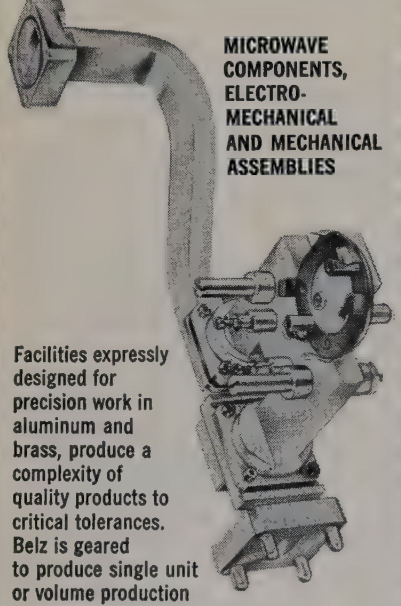
Livingston, New Jersey WYman 2-5700

B
+
18
PLUS

B + 18 PLUS = more than 18 years of engineering experience and production know-how in manufacturing advanced, reliable microwave components and assemblies.

Belz Industries' ability to meet critical requirements of military and industrial electronics firms has been consistently proven for almost two decades.

At Belz, skilled personnel, using advanced mechanical and electrical testing equipment . . . assures strict adherence to your specifications.



MICROWAVE COMPONENTS, ELECTRO-MECHANICAL AND MECHANICAL ASSEMBLIES

Facilities expressly designed for precision work in aluminum and brass, produce a complexity of quality products to critical tolerances. Belz is geared to produce single unit or volume production to the same critical standards.

Inquiries concerning development and/or manufacturing of microwave assemblies and system components are welcome. For descriptive brochure, or quotation on specific production problems, write, wire or call.

BELZ INDUSTRIES, INC.
89 UNION STREET • MINEOLA, N.Y.
Pioneer 2-1010

Industry News

(*Continued from page 70*)

LARSON NAMED TO EXHIBIT MANAGERS BOARD

Don Larson, manager of WESCON (Western Electronic Show and Convention), has been named to the board of directors of the National Association of Exhibit Managers.

His election to the executive group of the organization of professional exhibit managers took place at the recent annual meeting held at White Sulphur Springs, West Va.

Larson has been prominently identified with the West Coast electronics industry for the past 15 years. He was formerly advertising director for Hoffman Electronics Corp. and handled business affairs of the Western Electronic Manufacturers Association during a period when he had his own advertising agency serving the electronics industry.

He was appointed to the chief staff position of WESCON, the largest trade show and technical convention in the West, in the fall of 1956.

—*mwj*—

KIMMEL NAMED TO SALES STAFF

Robert O. Kimmel has been appointed western district sales manager for Hughes Aircraft Co.'s microwave tube division.

Before joining Hughes, Kimmel was the Raytheon Co.'s western area manager for special microwave devices, especially the ferrite component field. Previously he was Raytheon's senior west coast sales engineer for microwave tubes. He was also a field engineer for the General Electric Company on high powered radar equipment ultimately specializing in microwave tube equipment compatibility.

Kimmel is a graduate of the Polytechnic Institute of Brooklyn, and is a member of the IRE and the American Rocket Society.

—*mwj*—

AIR TRAFFIC CONTROL CENTER PLANNED

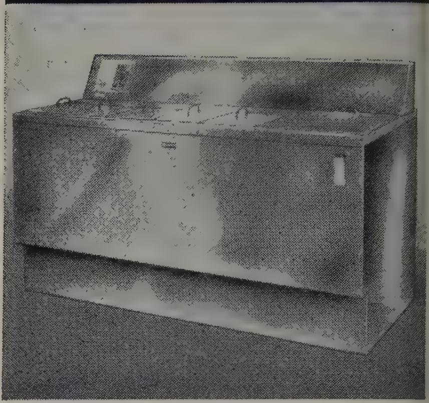
Electronic & Missile Facilities Inc., N. Y., N. Y. will build a $1,712,000 air traffic control center at Slidell, La., for the Federal Aviation Agency, it was announced by Arnold H. Kagan, Electronic's Board Chairman.

These facilities, to be completed within 11 months, will aid in the guidance and control of commercial aircraft in the latter's approach to New Orleans, Mr. Kagan said. They are part of the FAA's program to establish adequate and up-to-date air traffic controls in important centers throughout the country.

The contract was signed in Fort Worth, Tex., by Cecil R. Green, contracting officer for FAA, Second Regional Office.

—*mwj*—

BARNSTEAD ENGINEERED
TRANSISTOR WASHER



WITH GREATER CAPACITY for WASHING and RINSING

- TRANSISTORS
- DIODES
- MISSILE PARTS
- LARGE POWER TUBES
- ELECTRONIC PARTS

The new Barnstead Model TW-50X Transistor Washer, completely enclosed in stainless steel cabinet, was engineered for washing and rinsing transistors, diodes, missile parts, large power tubes and other electronic parts in hot, ultra pure water with continuous repurification. It produces best results with faster rinsing and fewer rejects.

The purification system continuously repurifies the water by (1) removal of organic impurities, (2) demineralization and (3) filtration of submicroscopic particles to 0.45 microns. RESULT: Ultra-pure final rinse water which is not only of high electrical resistance, (15,000,000 to 18,000,000 ohms @ 18° C., but also free of organic impurities and minute particulate matter which often interfere with thorough cleaning.

A minimum amount of heat is required since the system contains its own regenerative heat exchanger. The water is continuously recirculated and repurified, thus saving thousands of gallons of pure water daily, and eliminating the need for a larger capacity purification system.

Reduce your costs . . . cut down on rejects . . . write Barnstead for literature on the Transistor Washer Model TW-50X.

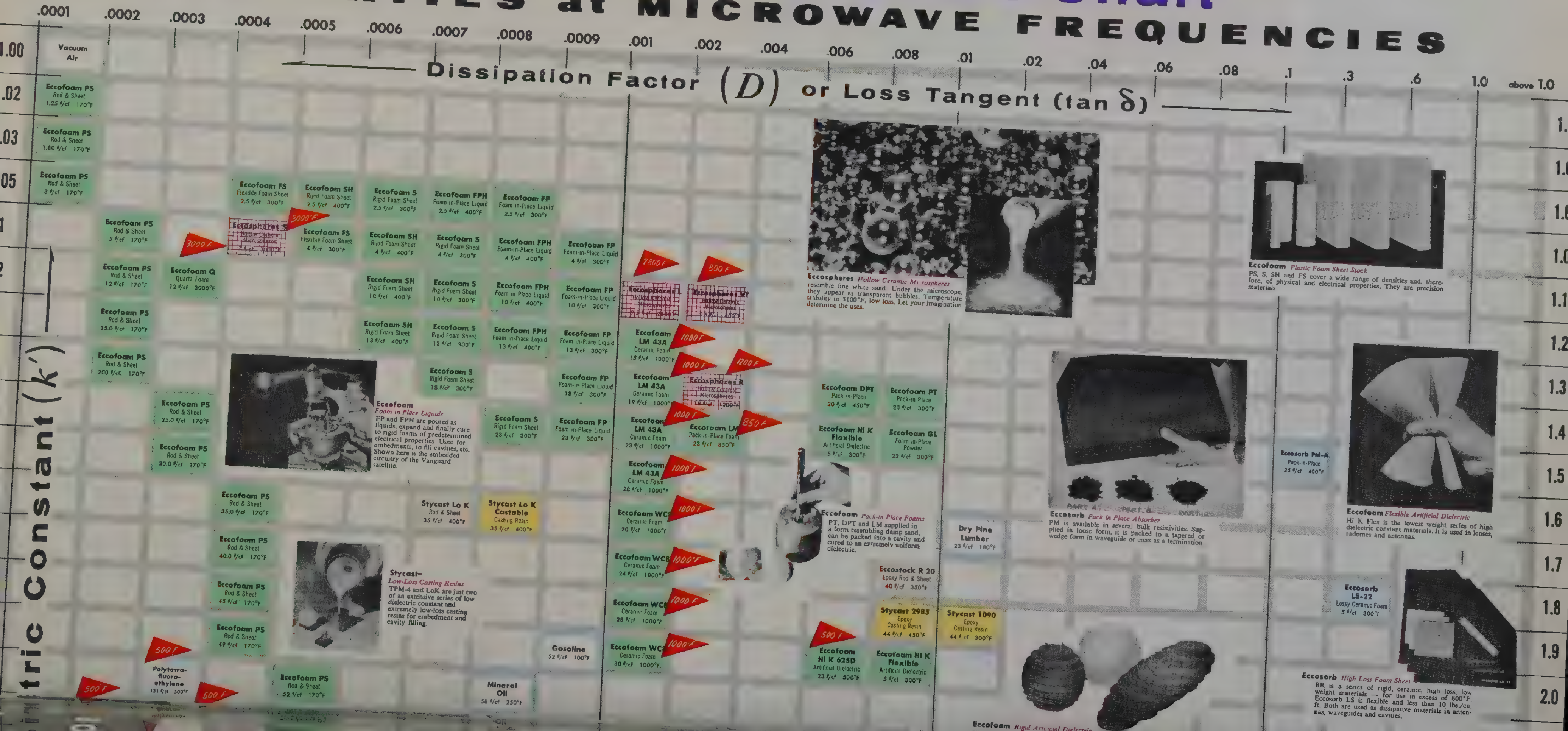
Barnstead®
STILL AND STERILIZER CO.
48 Lanesville Terrace, Boston 31, Mass.

FIRST IN PURE WATER

Emerson & Cuming, Inc.

Dielectric Materials Chart

PROPERTIES at MICROWAVE FREQUENCIES



Eccofoam *Foam in Place Liquids*
FP and FPH are poured as liquids, expand and finally cure to rigid foams of predetermined electrical properties. Used for embedments, to fill cavities, etc. Shown here is the embedded circuitry of the Vanguard satellite.

Stycast— *Low-Loss Casting Resins*
TPM-4 and LoK are just two of an extensive series of low dielectric constant and extremely low-loss casting resins for embedment and cavity filling.

Eccospheres *Hollow Ceramic Microspheres* resemble fine white sand. Under the microscope, they appear as transparent bubbles. Temperature stability to 3100°F, low loss. Let your imagination determine the uses.

Eccofoam *Pack-in Place Foams*
PT, DPT and LM supplied in a form resembling damp sand, can be packed into a cavity and cured to an extremely uniform dielectric.

Eccosorb *Pack in Place Absorber*
PM is available in several bulk resistivities. Supplied in loose form, it is packed to a tapered or wedge form in waveguide or coax as a termination

Eccofoam *Plastic Foam Sheet Stock*
PS, S, SH and FS cover a wide range of densities and, therefore, of physical and electrical properties. They are precision materials

Eccofoam *Flexible Artificial Dielectric*
Hi K Flex is the lowest weight series of high dielectric constant materials. It is used in lenses, radomes and antennas.

Eccosorb *High Loss Foam Sheet*
BR is a series of rigid, ceramic, high loss, low weight materials — for use in excess of 800°F. Eccosorb LS is flexible and less than 10 lbs./cu. ft. Both are used as dissipative materials in antennas, waveguides and cavities.

Eccofoam *Rigid Artificial Dielectric*

Emerson &

EMERSON & C

Trade Name/General Use	Designation	Physical Properties Specific Gravity	Viscosity (with Catalyst) Centipoises R.T. (75°F)	Thermal Expansion Coefficient x 10-6/°C	Thermal Conductivity BTU/ft²/hr/°F/in.	Izod Impact ft. lbs./in. of Notch
Stycast® Casting Resins	Stycast TPM-4 ①	1.2	5,000	45	1.2	2.0
	" TPM-5 ①	0.98	5,000	100	1.1	3.0
	" 2850 GT	1.8	16,000 (100°F)	15	2.4	0.24
	" 1090	0.7	10,000	19	0.8	0.25
	" 2741	1.3	40,000	28	1.2	4.0
	★ " 2651	1.55	20,000	25	1.5	0.3
	★ " 2651 MM	1.55	4,000	25	1.5	0.2
	" 2651-40	1.6	15,000	35	1.4	0.2
	" 2662	1.4	14,000	28	1.4	0.44
	" 2762	1.6	30,000	15	2.5	0.3
	" 2982 ①	1.5	4,000 (150°F)	25	1.45	0.9
	" 3020	1.5	5,000	18	1.9	0.8
	" 3050	1.45	1,000	30	1.5	1.0
	" 1231	1.4	20,000	30	3.1	0.3
	Ecco CPC-2	1.5	20,000	45	1.5	33*
	" CPC-6	1.1	10,000	50	1.8	80*
	★ " 3180 M	1.42	15,000	30	2.8	0.3
Eccosil Silicone and Epoxy-Silicones	Eccosil 4850	1.7	40,000	300	3.0	Elastomeric 48*
	" 4712	1.5	42,000	130	2.0	48*
	" 4640	0.85	86,000	170	1.8	75*
	" 4520	1.2	60,000	100	2.2	70*
						*Shore A-2 durometer
Eccocoat® Plastic Surface Coatings	Eccocoat E0200	1.2	500			
	" C26	1.2	2,000			
	" VE	1.2	Adjustable with thinner (low)			
	" D-30 ①	1.3	Viscous Liquid	30	2.5	0.5
Eccobond® Adhesives, Cements, Sealants	Eccobond 55	1.1	8,000	55		
	" 51	1.5	4,500	30		
	" 45	1.4	40,000	28		
	" 56C	3.7	Paste	12		
	" 58C	3.7	"	12		
	" 57C ①	3.7	"	12		
	" 70C	3.7	"	12		
	" 98 ①	1.4	Powder	40		
	" 104	1.6	Paste	25		
Eccoseal® Impregnating Resins	Eccoseal W28G ①	1.22	10 (300°F)			
	" W19	1.2	1,500			
	" 1207	1.2	10,000			
Eccoceram® Ceramic Encapsulents	Eccoceram SM25	1.8	10,000	12	2.6	0.2
	" CS	2.8	PASTE	15	3.0	0.2
	" 21	2.4	20,000	12	2.8	0.2
	" WL-52 ①	1.8	Viscous Liquid	8	2.6	0.2
	" QC	2.1	Variable /Pourable	1/2	2.5	0.2

Any of these E & C Resins
can be **Color Coded**
to meet your requirements

Technical Service and
Customized Formulation
are readily available.
Consult your nearest Representative.

① This indicates a
One Part System

Cuming Standar

ING, Inc., 869 Washington Street, Canton, Massa

	Electrical Properties				Interesting Features				
Machinability	Dissipation Factor 60cy-10KMC	Dielectric Constant 60cy-10KMC	Volume Resistivity Ohm-Cm 20°C/150°C	Dielectric Strength Volts/MIL 20°C	Maximum Use Temperature °F		Minimum Use Temperature °F	Major Physical Characteristics	Outstanding Properties
					Continuous	Intermittent			
Good	0.0003	2.2	10^{16}	450	450	550	−70	Tough, Hi Temp.	Electrical Excellence
Fair	0.0003	2.3	10^{16}	450	225	250	−70	Tough, Resilient	Electrical Excellence
Must Grind	0.02	4.7	$5x10^{16}/1x10^{13}$	455	350	400	−100	Extremely Rugged	Dimensional Stability
Good	0.015	1.9	10^{13}	300	300	400	−100	Light Weight	Adhesion
Fair	0.02	3.5	10^{14}	400	300	375	−90	Flexible	Adjustable Flexibility
Fair	0.02	4.4	$5x10^{16}/1x10^{13}$	455	400	500	−100	Very Strong and Easy to Handle	Adhesion Shock Resistance
Excellent	0.02	4.2	$4x10^{16}/7x10^{12}$	440	400	500	−100	Exceptional Handleability	Low Viscosity and Hi. Temp. Resistance
Good	0.02	4.2	10^{13}	400	400	500	−70	Exceptional Flowability At Room Temperature	Adhesion
Fair	0.011	3.4	10^{16}	420	500	600	−55	High Temperature & Moisture Resistance	I. R. at Hi. Temp.
Grind	0.012	3.5	10^{16}	410	500	600	−90	Fair Thermal Conductivity	Thermal Shock Resistance
Excellent	0.01	3.5	10^{16}	450	450	500	−80	Excellent Low Temp. Stability	Thermal Shock Resistance
Excellent	0.03	4.5	$2 x 10^{15}$	450	350	400	−65	Low Viscosity No Shrinkage	
Excellent	0.03	4.4		400	350	400	−100	Very Low Viscosity Very Low Shrinkage	
Excellent	0.02	4.2	10^{12}	400	300	350	−55	Easy to Cure; Quick Curing	Self-extinguishing
Poor	0.03	7.0	10^{11}	230	200	225	−90	Tough, Rubbery	Adhesion
Poor	0.04	6.0	10^{13}	300	250	275	−70	Rubbery	Adhesion; Toughness
Excellent	0.02	4.0	10^{12}	430	300	325	−55	Outstanding Moisture Resistance	Easy to Use
Poor	0.02	4.0	10^{14}	550	600	650	−80	Hi. Temp. Flexibility	Thermal Shock Resistance
Poor	0.02	4.2	10^{14}	450	450	550	−60	Hi. Temp. Adhesion	Adhesion to Silicones
Poor	0.015	2.5	10^{13}	350	600	650	−80	Low Weight per Unit Vol.	Thermal Shock Resistance
Poor	0.02	4.1	10^{14}	410	450	550	−60	Low Viscosity At High Temperature	Adhesion to Silicones
	0.01	2.9	10^{13}	480	300	400	−70	Clear	Easy to Spray
	0.01	3.0	$5 x 10^{16}$	500	450	600	−70	High Temperature	I. R. at Hi. Temp
	0.01	3.5	10^{12}	400	300	350	−70	Tough, Resilient	Shock Resistance
Good	0.02	3.9	10^{13}	350	300	350	−80	Thixotropic At Dip Temperature	Adhesion; Moisture Resistance
Excellent	0.015	3.3	$5 x 10^{16}$	440	350	400	−70	Rigid	Adhesion
Excellent	0.02	3.5	10^{16}	450	400	500	−80	Rigid	Adhesion, Low Visc.
Fair	0.02	3.2	$3 x 10^{13}$	410	300	400	−70	Flexible	Hi Peel Strength
Good			0.1		350	450	−70	Conductive	Low Curing Temp.
Good			0.1		1000		−65	Conductive	Hi. Temp. Resistance
Good			0.1		300	350	−70	Conductive	Room Temperature Cure
Good			0.1		300	350	−70	Hard; Coarse	Electrically and Thermally Conductive
Excellent	0.02	4.0	10^{15}	450	400	450	−70	High Bond Strength At High Temperature	A Dust-on Type Adhesive
Excellent	0.015	4.1	$10^{16}/10^{13}$	450	400	550	−70	Dimensionally Stable Adhesive Over a Wide Temperature Range	Readily Bonds Dissimilar Materials
Excellent	0.02	3.4	$2.3x10^{16}/4x10^{12}$	412	400	482	−70	Resilient	Thermal Shock Resistance
Good	0.02	3.5	10^{12}	400	300	350	−55	Low Viscosity	Ease of Use
Good	0.015	3.5	10^{14}	450	350	450	−55	Low Viscosity	High Temp. Impregnant Easy to Cure
Grind	0.004	4.2	$10^{11}/10^{7}$ @ 1000°F	100	2000	5000	−70	Resistant to Nuclear Radiation!	2000°F Thermal Shock Resistance
Grind	0.01	5.0	10^{10}	100	2000	5000	−80	Adjustable Viscosity	Adhesion!
Grind	0.006	7.0	$10^{12}/10^{7}$ @ 1000°F	150	2500	5000	−70	No Shrinkage	Electrical Excellence
Grind	0.01	5.0	$10^{11}/10^{5}$ @ 1000°F	100	1500	2000	−70	Low Shrinkage	Good Adhesion
Grind	0.001	4.0	$10^{11}/10^{7}$ @ 1000°F	100	2200	5000	−70	Essentially Vitrified Silica	Electrical Excellence

Dielectric Constant (κ')

2.4
2.5
3.0
3.5
4.0
4.5
5.0
6.0
7.0
8.0
9.0
0.
1.
2.
3.
4.
5.
6.
7.
8.
9.

60 #/cf 250°F

58 #/cf 170°F

60 #/cf 250°F

ethylene
131 #/cf 390°

2000°F
Fused Quartz
142 #/cf 2000°F
κ' — 3.8

2000°F
Fused Silica
142 #/cf 2000°F
κ' = 3.8

Stycast 0005
Rod & Sheet Stock
66 #/cf 300°F

Eccoseal HI Q
Impregnant
200°F

Polystyrene
64 #/cf 170°F

Eccofoam PS
Rod & Sheet
60 #/cf 170°F

Stycast 35
Casting Resin
60 #/cf 200°F

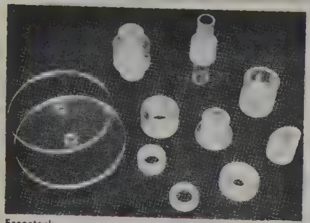
3500°F
Beryllium Oxide
187 #/cf 3500°F

Eccomold L65
Laminating Resin
300°F

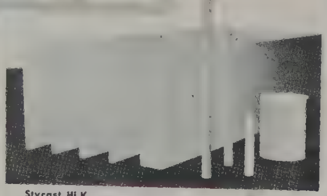
Stycast 62
Impregnant
300°F

Sulfur
125 #/cf 200°F

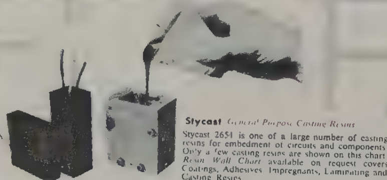
3000°F
Alumina
225 #/cf 3000°F



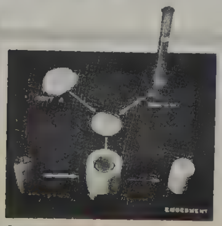
Eccostock
Low Loss, High Temperature Rod and Sheet
Eccostock HT 0003 is excellent for machined parts of low loss and no cold flow. Stycast Lo K is unsurpassed for insulators in waveguide, coax and antennas. Both are high temperature materials



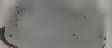
Stycast Hi K
Adjusted Dielectric Constant Rod and Sheet
A complete series of low loss materials. Sheets up to 2 ft x 2 ft are made. Easily machined and cemented. Stycast Hi K 500 F extends the temperature limit and dielectric constant range of the standard Stycast Hi K



Stycast *General Purpose Casting Resins*
Stycast 2651 is one of a large number of casting resins for embedment of circuits and components. Only a few casting resins are shown on this chart. *Resin Wall Chart* available on request covers Coatings, Adhesives, Impregnants, Laminating and Casting Resins



Eccoceram *Ceramic Dielectric for 2000°F*
SM-25 is castable as illustrated above. It is one of several ultra high temperature ceramics. Eccoceram Hi K is sheet stock of accurately controlled dielectric constant and low loss. Other Eccocerams are adhesives.



Eccofoam *Ceramic Foams*
LM-43A and WC8 are a series of sheet stocks usable in excess of 1200°F. Losses remain low at elevated temperature. Molded piece is unaffected by blow torch flame.

500°F
Stycast HI K 500 F
Rod & Sheet
83 #/cf 500°F

Stycast HI K
Rod & Sheet
81 #/cf 250°F

500°F
Stycast HI K 500 F
Rod & Sheet
90 #/cf 500°F

Stycast HI K
Rod & Sheet
89 #/cf 250°F

500°F
Stycast HI K 500 F
Rod & Sheet
96 #/cf 500°F

500°F
Stycast HI K
Rod & Sheet
95 #/cf 250°F

Stycast HI K 500 F
Rod & Sheet
102 #/cf 500°F

500°F
Stycast HI K
Rod & Sheet
100 #/cf 250°F

Stycast HI K 500 F
Rod & Sheet
110 #/cf 500°F

500°F
Stycast HI K
Rod & Sheet
108 #/cf 250°F

Stycast HI K 500 F
Rod & Sheet
117 #/cf 500°F

500°F
Stycast HI K
Rod & Sheet
115 #/cf 250°F

Stycast HI K 500 F
Rod & Sheet
122 #/cf 500°F

500°F
Stycast HI K
Rod & Sheet
121 #/cf 250°F

Stycast HI K 500 F
Rod & Sheet
127 #/cf 500°F

500°F
Stycast HI K
Rod & Sheet
127 #/cf 250°F

Stycast HI K 500 F
Rod & Sheet
136 #/cf 500°F

500°F
Stycast HI K
Rod & Sheet
135 #/cf 250°F

Stycast HI K 500 F
Rod & Sheet
141 #/cf 500°F

500°F
Stycast HI K
Rod & Sheet
140 #/cf 250°F

Stycast HI K 500 F
Rod & Sheet
148 #/cf 500°F

500°F
Stycast HI K
Rod & Sheet
148 #/cf 250°F

Stycast HI K 500 F
Rod & Sheet
156 #/cf 500°F

500°F
Stycast HI K
Rod & Sheet
155 #/cf 250°F

Stycast HI K 500 F
Rod & Sheet
162 #/cf 500°F

500°F
Stycast HI K
Rod & Sheet
162 #/cf 250°F

500°F
Stycast HI K 500 F
Rod & Sheet
168 #/cf 500°F

500°F
Stycast HI K 500 F
Rod & Sheet
174 #/cf 500°F

500°F
Stycast HI K 500 F
Rod & Sheet
180 #/cf 500°F

500°F
Stycast HI K 500 F
Rod & Sheet
186 #/cf 500°F

500°F
Stycast HI K 500 F
Rod & Sheet
194 #/cf 500°F

500°F
Stycast HI K 500 F
Rod & Sheet
201 #/cf 500°F

500°F
Stycast HI K 500 F
Rod & Sheet
208 #/cf 500°F

500°F

1500°F
Eccoceram HI K
Ceramic Sheet
100 #/cf 1500°F

1500°F
Eccoceram HI K
Ceramic Sheet
125 #/cf 1500°F

1500°F
Eccoceram HI K
Ceramic Sheet
30 #/cf 1500°F

1500°F
Eccoceram HI K
Ceramic Sheet
140 #/cf 1500°F

1000°F
Borosilicate Glass
150 #/cf 1000°F

1000°F
Eccofoam WC8
Ceramic Foam
40 #/cf 1000°F

Eccofoam WC8
Ceramic Foam
50 #/cf 1000°F

1000°F
Eccofoam WC8
Ceramic Foam
60 #/cf 1000°F

1000°F
Eccofoam WC8
Ceramic Foam
70 #/cf 1000°F

Methyl Methacrylate
75 #/cf 170°F

1000°F
Stycast 40
Polyester Resin
66 #/cf 300°F

2000°F
Eccoceram SM 25
Castable Ceramic
112 #/cf 2000°F

1800°F
Steatite
162 #/cf 1800°F

2500°F
Eccoceram 21
Castable Ceramic
150 #/cf 2500°F

Vinyl Resin
85 #/cf 160°F

700°F
Silicone Laminate
120 #/cf 700°F

650°F
Glass Bonded Mica
186 #/cf 650°F

500°F
Eccofoam HI K 625D
Artificial Dielectric
25 #/cf 500°F

500°F
Eccofoam HI K 625D
Artificial Dielectric
25 #/cf 500°F

500°F
Eccofoam HI K 625D
Artificial Dielectric
25 #/cf 500°F

Stycast 2651
Epoxy
Casting Resin
100 #/cf 350°F

Eccomold L44
Fiberglass Laminate
(60% Glass)
110 #/cf 400°F

Nylon
69 #/cf 350°F
κ' — 2.8

Eccofoam HI K Flexible
Artificial Dielectric
5 #/cf 300°F

500°F
Eccofoam HI K Flexible
Artificial Dielectric
5 #/cf 300°F

500°F
Eccofoam HI K 625D
Artificial Dielectric
25 #/cf 500°F

Eccomold L28
Fiberglass Laminate
(62% Glass)
115 #/cf 350°F

500°F
Eccofoam HI K 625D
Artificial Dielectric
25 #/cf 500°F

1000°F
Porcelain
150 #/cf 1000°F

Eccofoam HI K Flexible
Artificial Dielectric
5 #/cf 300°F

500°F
Eccofoam HI K Flexible
Artificial Dielectric
5 #/cf 300°F

Eccofoam HI K 625D
Artificial Dielectric
25 #/cf 500°F

Eccofoam HI K 625D
Artificial Dielectric
25 #/cf 500°F

500°F

Eccofoam HI K Flexible
Artificial Dielectric
5 #/cf 300°F

500°F
Eccocoat C 26
Epoxy
Surface Coating
500°F

Eccoseal W28G
Epoxy Impregnant
500°F

500°F
Silicone Oil
500°F

500°F
Eccomold L28
Epoxy
Laminating Resin
350°F

Phenolic Resin Unfilled
78 #/cf 250°F

Eccobond 88
Epoxy Adhesive
400°F

Phenolic Paper Base Laminate
80 #/cf 225°F

Phenolic Molding Compound
Mica Filled
100 #/cf 300°F

Eccostock HI K
Rod & Sheet
A Series in dielectric constant range of 3.0 to 20 in steps of 1.0 with dissipation factor about 0.03

Eccosorb HF-2050
Rod/Sheet Absorber
65 #/cf 350°F

Eccosorb HF-1000
Rod/Sheet Absorber
70 #/cf 350°F

Eccosorb *Rod, Sheet and Moldable Absorber*
Eccosorb HF is a series — each material is in a specified bulk resistivity range and with appropriate dielectric properties. Shown is a variety of custom-molded parts. Material can be machined for terminations, attenuators and loads.

μ-1.0
Eccosorb MF 110
Rod/Sheet Absorber
102 #/cf 350°F

Eccosorb LS-24
Lossy Flexible Foam
7 #/cf 300°F

500°F
Eccosorb MF 500F-110
Rod/Sheet Absorber
μ-1.0

800°F
Eccosorb
Lossy Ceramic Foam
21 #/cf 800°F

Eccosorb PM-B
Pack-in-Place
28 #/cf 400°F

μ-1.1
Eccosorb MF-112
Rod/Sheet Absorber
129 #/cf 350°F

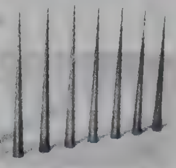
500°F
Eccosorb MF 500F-112
Rod/Sheet Absorber
130 #/cf 500°F
μ-1.1

800°F
Eccosorb
Lossy Ceramic Foam
23 #/cf 800°F

μ-1.3
Eccosorb MF-114
Rod/Sheet Absorber
185 #/cf 350°F

500°F
Eccosorb MF 500 F-114
Rod/Sheet Absorber
187 #/cf 500°F
μ-1.3

Eccosorb LS-26
Lossy Flexible Foam
10 #/cf 300°F



Eccosorb
Terminations for Waveguide and Coax
MF and MF 500 F are widely used to machine conical and pyramidal tapers. Low VSWR and high attenuation per unit length characterize the material. Tolerates temperatures to 500°F.

μ-1.8
Eccosorb MF-116
Rod/Sheet Absorber
218 #/cf 350°F

500°F
Eccosorb MF 500 F-116
Rod/Sheet Absorber
220 #/cf 500°F
μ-1.8

Eccosorb
Casting Resin Absorber
Eccosorb CR can be cast in molds to exact size to produce attenuators and terminations for waveguide and coax. In foreground are completed flap attenuators.

Eccosorb HF-853
Rod/Sheet Absorber
75 #/cf 350°F

μ-2.0
Eccosorb MF-116
Rod/Sheet Absorber
258 #/cf 350°F

500°F
Eccosorb MF 500 F-117
Rod/Sheet Absorber
260 #/cf 500°F
μ-2.0

Eccobond 60 C
Conductive Adhesive
450°F
ρ = 50 ohm-cm

Eccosorb CR
Casting Resin
μ-2.0

1
1
12
13
14
15
16.
17.
18.
19.
20.
21.

DEFINITIONS

A non-magnetic dielectric material is defined by real and imaginary components of the **Complex Permittivity**

$$\epsilon^* = \epsilon' - j\epsilon'' \text{ (farads/meter)}$$

Normalization of ϵ^* with respect to the **Dielectric Permittivity of Free Space**

$$\epsilon_0 = 10^{-9}/36\pi \text{ (farads/meter)}$$

gives the

Complex Relative Permittivity

$$\frac{\epsilon^*}{\epsilon_0} = \kappa^* = \kappa' - j\kappa''$$

where

Dielectric Constant κ' is the relative permittivity or relative dielectric constant. It is the quantity generally referred to as *Dielectric Constant* in the literature. It is plotted vertically on this chart and is a dimensionless quantity since it is relative to free Space.

Loss Factor κ'' is the relative loss factor. In the literature, it is usually given as *Loss Factor*. It should not be confused with Dissipation Factor or Loss Tangent as defined below.

Dissipation Factor
Loss Tangent
tan δ

Dissipation Factor (D), Loss Tangent and tan δ are identical. This is the quantity usually reported to indicate the energy loss characteristic of a material. Plotted horizontally on this chart, it is dimensionless and defined as follows:

$$D = \tan\delta = \frac{\kappa''}{\kappa'}$$

Note that the Loss Factor is the product of the Dielectric Constant and Dissipation Factor.

Power Factor

$$PF = \cos\theta = \frac{\tan\delta}{\sqrt{1+\tan^2\delta}} \underset{\text{approx.}}{=} \tan\delta$$

Power Factor is approximately equal to Dissipation Factor for values below 0.1.

Quality Factor

$$Q = \frac{1}{\tan\delta}$$

When applied to a dielectric material, it is comparable to the "Q" of circuit theory.

Dielectric Conductivity

$$\sigma_d = 5.5 \times 10^{-11} f \kappa'' \left[\frac{1}{\text{ohm-meter}}\right]$$

where f = frequency

Attenuation

$$A \underset{\text{approx.}}{=} 9.1 \times 10^{-8} f \tan\delta \sqrt{\kappa'} \left[\frac{\text{db}}{\text{meter}}\right]$$

This applies to the TEM mode.

Wave Impedance

$$Z \underset{\text{approx.}}{=} 377\sqrt{1/\kappa'}\left(1 + j\frac{\tan\delta}{2}\right) \text{ [ohms]}$$

Index of Refraction

$$n = \sqrt{\kappa'}$$

CHART EXPLANATIONS

Properties are average values for:

Microwave Frequency Range 10^9 to 3×10^{10} cps.
(Free Space Wavelength, from 30 cm to 1 cm)

and at

Room Temperature, 77°F (25°C)

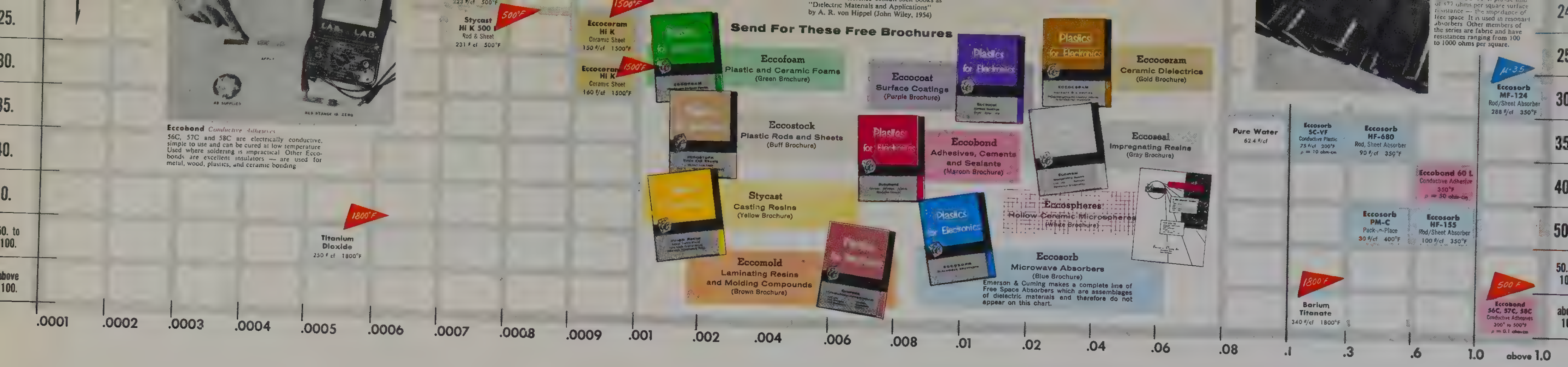
NOTE: Properties of all materials vary with both frequency and temperature. Consult appropriate Technical Bulletins of Emerson & Cuming Inc., or other source information.

Weight of each material is given in pounds per cubic foot (#/cf)
To convert to density in grams per cubic centimeter (g/cc) divide by 62.4

High Temperature Safe working limit for each material is given in degrees Fahrenheit (°F)
To convert to degrees Centigrade (°C) subtract 32 and multiply result by 5/9

Color Code All Emerson & Cuming products are shown in color blocks corresponding to that of the brochure in which the Technical Bulletin appears. Consult the appropriate brochure and Technical Bulletin for more information.

F — Indicates a high temperature material usable above 500°F. Actual safe-use temperature is noted in the flag (°F).



"Dielectric Materials and Applications"
by A. R. von Hippel (John Wiley, 1954)

Eccobond *Conductive Adhesives*
56C, 57C and 58C are electrically conductive, simple to use and can be cured at low temperature. Used where soldering is impractical. Other Eccobonds are excellent insulators — are used for metal, wood, plastics, and ceramic bonding.

Emerson & Cuming makes a complete line of Free Space Absorbers which are assemblages of dielectric materials and therefore do not appear on this chart.

of 377 ohms per square surface resistance — the impedance of free space. It is used in resonant absorbers. Other members of the series are fabric and have resistances ranging from 100 to 1000 ohms per square.

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San Diego 9, California
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Jefferson 1-7765

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Orchard 5-6700

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Winton 1-2700

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Dayton 7, Ohio
Crestview 8-4779

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West 9-7891

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Resins

usetts

NEW Epoxy/Silicone Properties Chart

Major Uses							
Trans- ormers	Coils	Circuitry	Component Protection	Metal Adhesive	Plastic Adhesive	Important Specific Applications	GENERAL REMARKS
✓	✓	✓				Low Loss Embedments — Hi. Temp. ❶	Class A, Mil I 16923C Type Material with Class D Temp. capability
✓	✓	✓				Waveguide Filling; Antennas ❶	Class A, Mil I 16923C Type Material
+✓		✓		✓		Potting of Impregnated Transformers	Practically indestructible within its temp. limits. Amazing vibration resistance
✓		✓				Instrument Transformer Potting	Thixotropic at room temp., needs lots of stirring
+✓		✓	✓	✓	+✓	Mil-T27 Transformers	Widely used as adhesive
+✓	✓	+✓	+✓	+✓	+✓	Capacitor End Filling	Best all-around material available — Self extinguishing 2651-FR ★
+✓	✓	✓	+✓	✓	✓	Potting Amplifier Circuits	Really flows at room temperature! Self extinguishing 2651 MM-FR ★
✓	✓	✓	✓	✓	✓	Micromodules	Exceptionally easy to use
✓			✓	+✓		Resistor Embedment	Complete(!) moisture resistance, hard to use. Not for amateurs
		✓	✓	✓		Hi. Temp. Rigid Connectors	Thixotropic; lots of hard stirring
+✓	✓	✓	✓	+✓	✓	Transformer Potting ❶	Will also impregnate Class D Type mat'l Mil I 16923C
	✓	✓	✓			Diode Sealing	Very simple to use; a junior grade 2651
	✓	✓	+✓			Magnetic Clutch Coil Embedment	Impregnates and pots simultaneously
✓	✓	✓				Component Circuitry	This resin is immediately self-extinguishing after repeated firings
✓			✓	✓		Connector Potting	Polysulfide Rubber
			✓	✓	+✓	Connector Potting; Sealant	Polyurethane Rubber
+✓	+✓	✓	✓			Transformer & Coil Potting	Low cost — opens NEW fields for expoxy! ★
✓	✓		✓			Transformer Potting; Tooling	RTV Silicone; Easy to use
			✓	✓	✓	Connector Potting	This is the permanently flexibilized Epoxy
✓	✓		✓			Low Weight Thermal Barriers	Missile men take note — RTV
✓	✓		✓	✓	✓	Hi Temp. Adhesive	600°F organic adhesive!
		✓				Foam Coating	General purpose — good adhesion
	+✓	+✓	✓			Corrosion Protection Alum. Dipped Capacitors	Long Cure but worth it Very high moisture resistance
✓	✓	✓	✓			Printed Circuit Coating	Very easy to apply; Very easy to cure
						Transformer Dip-coating ❶	Will not flow after dipping · beautiful coatings! Self-extinguishing-Eccocoat D-30-FR
				✓	✓	Pots	All pot mfgs. should use it; most do
				+✓	✓	Metal to Metal; Metal to Ceramic	Very Easy To Use; general purpose, packaged in Kits
				✓	✓	TV Tube Bases (Nylon to Glass Seal)	Best nylon-adhesive we know
						Printed Circuits	Not easy to use — but what else is like it; except —
						Hi. Temp. De-Icers ❶	— This stuff (1000°F)
						Printed Circuits	Finally — a fool proof conductive epoxy. Room temperature curing!
✓	✓	✓	✓	✓	+✓	R.F. Gasketing	Has high R.F. insertion loss. Shielding mfs. note!
				+✓	✓	Stator Laminations ❶	This is probably the simplest epoxy to use of them all
				+✓	+✓	High Temperature Pots	Probably the best high temperature epoxy system on the market
+✓				+✓	✓	Class H Transformers-various ❶	Best epoxy impregnant on market
✓	✓					Capacitors	Like water, when warm
✓	✓		✓	✓		Dipped Capacitors	The best component moisture seal we have
+✓	✓	✓	✓			Ceramic Resistors	Very easy to cure
				+✓	✓	Metal — Metal Adhesive	Ceramic with good adhesion — what the world has been waiting for
✓	✓	✓	+✓			Transformer Potting	Let us repeat — 5000°F! Electrically terrific!
				✓		Ceramic to Metal Adhesive ❶	This material has the best adhesion of any inorganic known to us
✓			✓			Inorganic Cement	Curable at 400°F maximum to produce a true silica

+✓ Indicates an
Outstanding Product for
his Specific Application

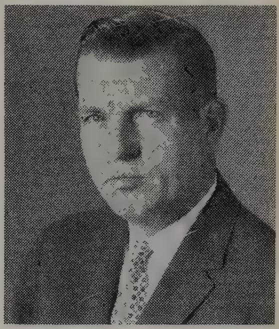
Revised 1/9/61

CONTRIBUTORS IN THIS ISSUE

ASAF A. BENDERLY was born in 1922. He received a BChE degree in 1944 from the City College of New York and an MChE in 1953 from the Polytechnic Institute of Brooklyn.

In 1944 and 1945 he participated in the "Manhattan Project" as a chemical engineer at the Houdaille-Hershey Corp., Decatur, Illinois. From 1945 to 1947 he served on active duty with the U.S. Army. Following a period of graduate study, Mr. Benderly joined the staff of the National Bureau of Standards in 1950 as a physical chemist doing research in the field of electrodeposition.

Since 1953, Mr. Benderly has been a member of the staff of the Diamond Ordnance Fuze Laboratories, Washington, D.C., during which time he has specialized in polymers, dielectrics and other electrical materials. He is currently the Chief of the Materials Branch of these Laboratories.



MOTHY J. KILDUFF was born in Frostburg, Maryland on October 10, 1920. e received his BS degree in Chemistry in 1950 from Davis-Elkins College.

From 1946 to 1953, he was with the Organic and Fibrous Materials Division of e National Bureau of Standards, engaged in the development of synthetic and tural resins for impregnants in leather.

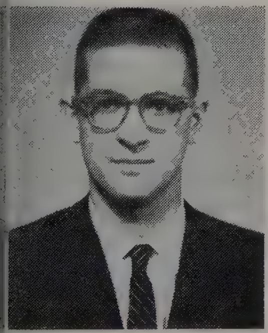
Mr. Kilduff joined the Materials Division of the Diamond Ordnance Fuze boratories in 1953, and since that time has specialized in the research and develop-ent of adhesives for ordnance applications. He is a member of the American emical Society, and the D-14 Committee of the American Society for Testing aterials.

S. ROSENBLUM received ME and BS (AE) degrees from Cornell University in 36 and 1937, respectively.

From 1937 to 1941 he was a mechanical engineer with a manufacturer of ectric motors and was maintenance manager of a department store. During the ar, Mr. Rosenblum served in the Navy and Marine Corps as a member of the orking Committee of the Aeronautical Board and as engineering officer of a ghter squadron.

From 1946 to 1952 he was a teaching and research assistant at Case Institute of echnology and while there he received MS and PhD degrees in nuclear physics in 49 and 1952.

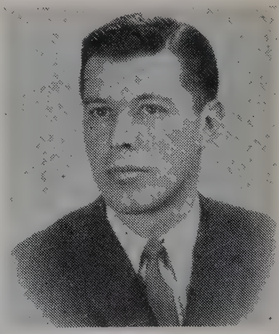
Mr. Rosenblum became a member of the MIT Lincoln Laboratory in 1952 and presently involved in semiconductor physics, radar components, propagation, low mperature and vacuum technology.



ANTHONY E. SIEGMAN graduated from Harvard College in 1952, and then joined the Hughes Research Laboratories under their Cooperative Plan, working on slow-wave circuits and traveling-wave tubes. After receiving an MS degree in applied physics from UCLA in 1954, he continued his graduate study at Stanford University, and received a PhD degree in electrical engineering in 1957. His thesis work concerned microwave noise fluctuations in electron beams.

Since then he has been a member of the Stanford faculty, presently as Associate Professor of Electrical Engineering. His research work is concerned with solid-state and traveling-wave masers, and other topics in microwave physics.

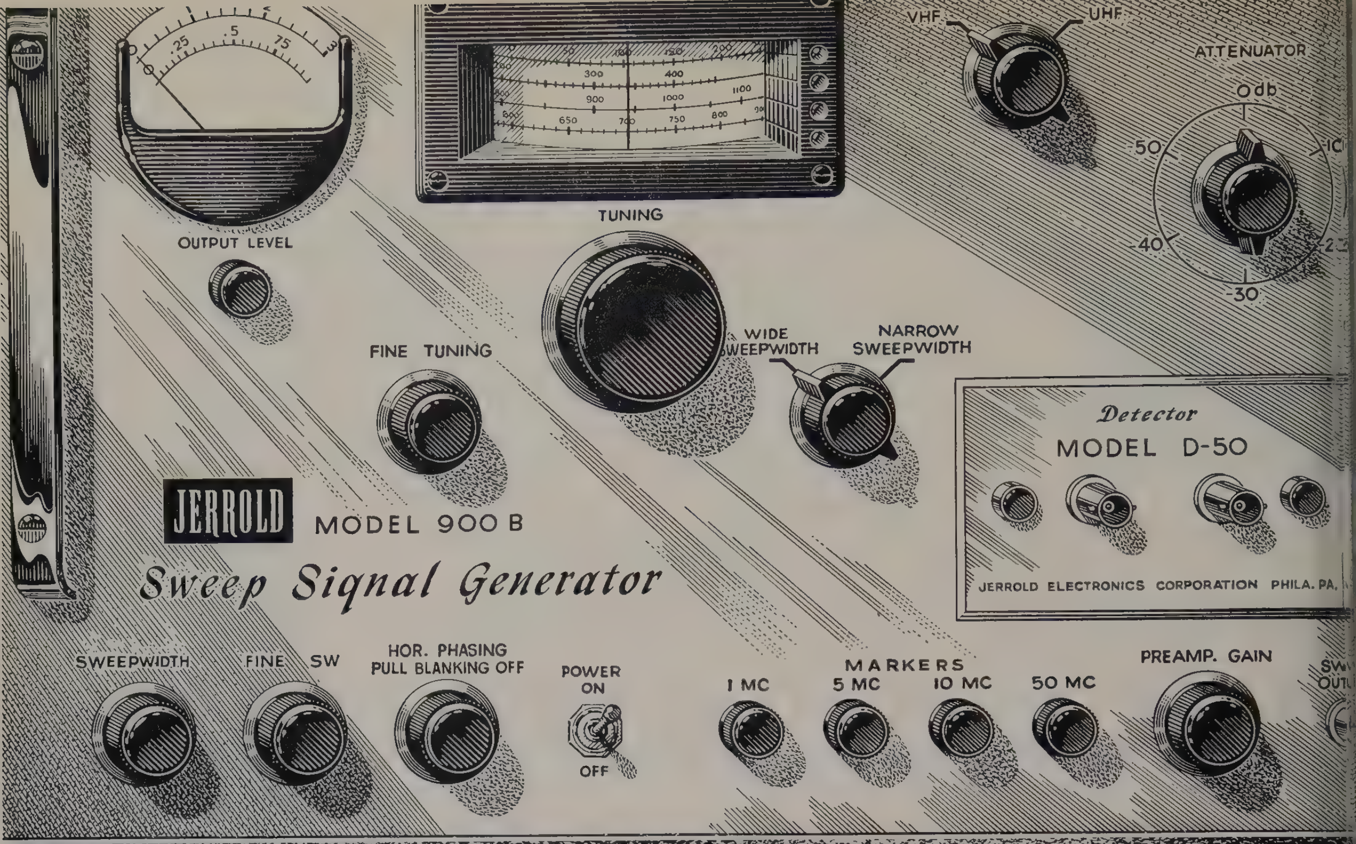
Mr. Siegman is a member of The American Physical Society, American Vacuum Society and Sigma Xi.



RNEST J. WILKINSON received a BS degree in electrical engineering from ortheastern University, Boston, Mass. in 1952 and an MS degree in electrical en-neering from Stanford University, Stanford, California, in 1956.

From 1952 to 1953 he was employed by Sandia Corporation, Albuquerque, ew Mexico. He has been associated with Sylvania Electric Products, Inc. since 953, and is currently an engineering specialist in their Antenna and Microwave aboratory located in Waltham, Mass.

Mr. Wilkinson is a member of Tau Beta Pi and Eta Kappa Nu.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THERMAL NOISE IN MICROWAVE SYSTEMS

Part 1

Fundamentals

A. E. SIEGMAN

ASSOCIATE PROFESSOR
Electrical Engineering

STANFORD UNIVERSITY
Stanford • California

INTRODUCTION

Most microwave engineers are familiar with the equiva-nt voltage or current generators used to represent ther-al noise generation in a resistance. These equivalent enerators can be applied to microwave circuits also, pro-ded that the microwave circuit elements are converted to equivalent lumped-circuit elements. There is, how-ver, an alternative way of approaching noise problems n microwave circuits which is often more convenient and ore understandable than the lumped-circuit equivalent-enerator method. This alternative approach is the prac-ce of considering always forward- and backward-travel-g noise waves in sections of transmission lines, rather an noise voltages and currents in lumped elements. This pproach is certainly not novel. However, it is not as idely used as it might be. There are many instances here the transmission-line viewpoint avoids difficulties hich arise in the lumped-circuit method. The transmis-on-line approach allows clear and unambiguous tracing f the sources and paths of noise in complex circuits and in onreciprocal or negative-resistance devices. Moreover, it mphasizes the more important concept of temperature, hile deemphasizing the less important concept of im-edance level. Therefore, this first article is devoted to xploring the transmission-line approach to noise and ome of its consequences.

THERMAL NOISE WAVES IN LOSSLESS TRANSMISSION LINES

The Low-Frequency Lumped-Circuit Case

Consider a resistance R which is in thermal equilibrium t temperature T. As most engineers know, such a re-stance will have in a bandwidth B a mean-square noise oltage across its open-circuited terminals given by

$$e_n^2 = 4kTRB \tag{1}$$

The quantity 4kTR is the power spectral density, i.e., its nits are $(\text{volt})^2$ per unit frequency bandwidth. When ultiplied by a bandwidth B, the result is $(\text{volt})^2$. This oise voltage is called the thermal or Johnson or Nyquist oise voltage of the resistor. It is commonly indicated y putting a noise voltage generator of this mean-square alue in series with the resistance, as shown in Figure 1a. t is, of course, possible to replace the noise voltage gene-ator by its Thevenin equivalent, a shunt noise current generator of mean-square value $i_n^2 = 4kTB/R$, and this equivalent form is often used. Since both the physics of the situation and the important mathematical results are the same for either choice, we will stick to the noise voltage form only.

If the resistance R and its noise generator are connected to a matched load resistance $R_L = R$, as shown in Figure 1b, then the noise power P_n dissipated in the load resistance R_L due to the noise voltage generator of the original resistance R will have the maximum possible value, namely

$$P_n = kTB \tag{2}$$

This is usually referred to as the *available noise power* from the original resistance. It takes no account of the noise power which the load resistance R_L may simultaneously be generating and transferring back to the original resistance R. Moreover, Equations 1 and 2 are really only the low-frequency approximations to exact forms which we will give a little later.

When one considers the resistors and noise voltage generator of Figure 1b, it may seem reasonable to ask whether the noise voltage generator of the original resistance R dissipates noise power in the original resistance R as well as in the load resistance R_L. Certainly the noise currents created by e_n^2 flow through both resistances. However, this is not really a sensible question to ask; and in some situations asking this question or a variant of it can lead to considerable confusion. Fortunately, the question and the resultant confusion can be entirely avoided by consistent use of the transmission-line viewpoint referred to in the introduction.

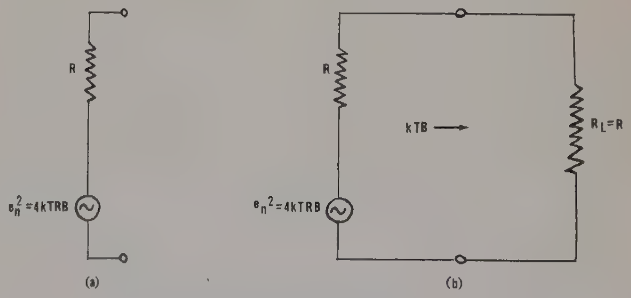


Figure 1 — (a) The Johnson noise voltage in a resistor R is $e_n^2 = 4kTRB$. (b) The available noise power to a matched load is $P_n = kTB$.

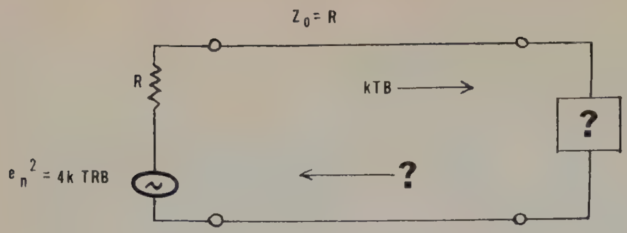


Figure 2 — A resistance R will deliver noise power $P_n = kTB$ to the outgoing wave in a transmission line matched to R.

The Transmission-Line Approach

Suppose that the resistance of Figure 1a is connected to an arbitrary length of lossless transmission line whose characteristic impedance is matched to the resistance, $Z_0 = R$, as shown in Figure 2. For our purposes at the minute, we need not specify what is connected to the other end of the transmission line. The important point is that the noise voltage of the original resistance will create on the transmission line an outgoing noise wave of power $P_n = kTB$, the available noise power, no matter how the line is terminated. The reader can verify the last phrase for himself by calculating for an arbitrary terminating impedance. The outward-traveling wave of noise voltage and current carries noise power $P_n = kTB$ to the right regardless of what is connected to the outer end of the line.

In addition, there will be an incoming wave of noise voltage and current traveling to the left, the magnitude of which will depend on what is connected to the other end of the transmission line. The other end may have another matched resistance, which will send back its own kTB; or there may be a partial or complete mismatch, which will reflect back some or all of the outgoing noise plus adding some new noise; or there may even be a negative-resistance device which will send back the original noise greatly amplified. In any case, all of the noise wave traveling to the left will be completely absorbed by the resistance R since it forms a matched termination to the transmission line.

The transmission-line viewpoint means always thinking of noise quantities in terms of these traveling waves on transmission lines. Noise voltages and currents are replaced by wave amplitudes in this viewpoint. The noise voltage generator of a resistance is replaced by the statement that a terminating resistance creates an outgoing wave of power $P_n = kTB$ in a matched transmission line. The transmission-line viewpoint can be used even in lumped-circuit calculations, where no transmission lines are present, by the following artifice. In front of every resistance one must insert, at least conceptually, an arbitrary length of transmission line matched to the resistance, as shown in Figure 3. The arbitrary length of line can have no effect on the performance of the circuit, since the impedance at the terminals of the transmission line is still just the resistance R regardless of line length or frequency of measurement. The noise power furnished by or the noise power dissipated in the resistance R can then be defined as the noise power in the outgoing and incoming transmission-line waves, respectively. The outgoing noise power is always $P_n = kTB$ regardless of the remainder of the circuit. The incoming noise power depends on what is in the remainder of the circuit.

It is now clear when and how a resistance can dissipate its own noise power. If an impedance mismatch or

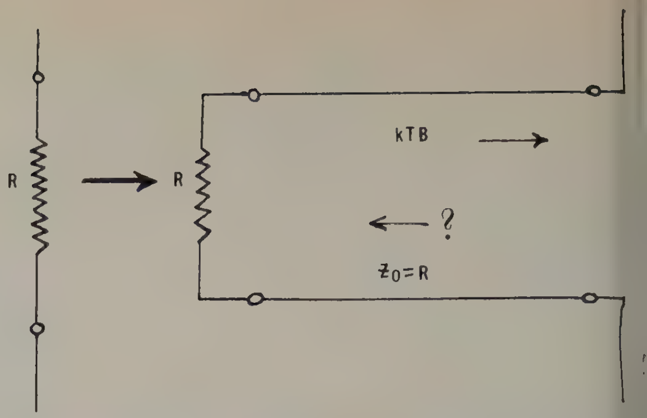


Figure 3 — Replacing a resistance R by the same resistance plus a length of matched transmission line will not alter the circuit performance in any way.

negative resistance is seen looking outwards along the transmission line away from the resistance, then some of the outgoing noise power $P_n = kTB$ will be returned and will be absorbed in R. With negative resistance in the termination, the returning power may even be amplified. This situation is confusing when described in terms of lumped elements and equivalent generators, but when the transmission-line waves are used it is perfectly clear what the source of the noise is and where it goes.

The forward- and backward-traveling waves on a transmission line are not just mathematical abstractions but are measurable physical quantities. They can be separated and measured by, for example, using directional couplers. Another way is to use an ideal circulator connected into the transmission line as shown in Figure 4. By putting a short circuit on either port 2 or port 4, the wave in one direction will be unaltered. The wave in the other direction can either be tapped off for measurement, or can be reflected unaltered from an open circuit while simultaneously being measured with a high-impedance r-f voltmeter.

More Complex Transmission Lines and Waveguides

The statements just made concerning noise waves certainly apply to simple TEM transmission lines which possess a simply defined voltage and current. However, the statements are equally valid for waveguides and other more complex types of transmission lines which carry

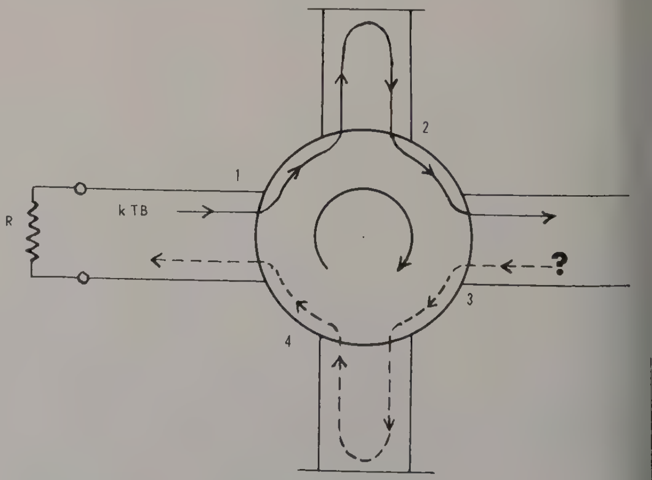
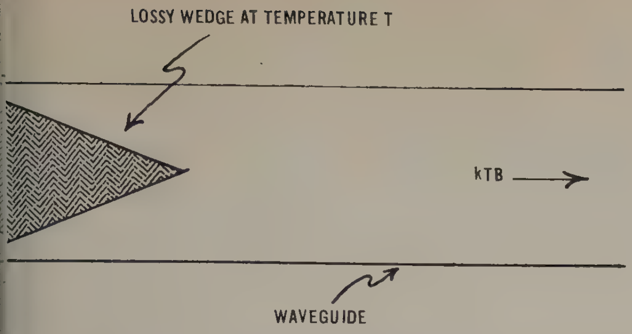


Figure 4 — An ideal circulator can be used to separate the outgoing and incoming waves on a transmission line for separate measurement.



igure 5 — The waveguide termination sends noise power P_n = kTB down the rectangular waveguide.

ower but which do not have simply defined voltages and urrents. Consider, for example, a TE_{10} rectangular waveuide terminated at one end by a wedge of lossy material temperature T, as shown in Figure 5. This termination ill deliver a noise power $P_n = kTB$ to the waveguide, st like a terminating lumped resistance, and this noise ower will propagate out to the right as a TE_{10} wave in e waveguide. Note that there is no longer a simply efined noise voltage or current, but there is a definite ave which carries a definite power. We can say, in eneral, that any termination which terminates a waveuiding system will generate and send out along that sysm a noise wave of power $P_n = kTB$ corresponding to e temperature T of the termination.

Still More Fundamental Statement

The statement just made is actually valid only at 'low' equencies, and it implies that the wave-guiding system a single-mode system. A still more fundamental stateent — in fact, about the most fundamental statement we n conveniently make — is the following: Consider any rmination at temperature T which terminates a propaiting mode or wave in any wave-guiding system. Such a rmination will generate and send back out into that ode a thermal noise wave carrying noise power P_n ven by

$$P_n = \frac{hfB}{\exp(hf/kT) - 1} \qquad (3)$$

his statement comes from quantum thermodynamics, and ust be accepted for our purposes as a basic law of nature. applies not only to electrical systems, but also to any nd of energy-carrying wave-propagating system. Conder, for example, a solid rod which will propagate one more acoustic or mechanical waves. A termination hich terminates such an acoustical wave will also gente and send out in such a wave acoustical thermal noise ower given by Equation 3. In fact, the thermal lattice brations present in every solid simply represent the sum tal of all the acoustic noise waves in all directions at l frequencies.

Equation 3 gives the noise power P_n per mode. If the ave-guiding system propagates several modes, there will separate and uncorrelated noise waves with noise power $_n$ in each of the modes. For example, if the waveguide Figure 5 is examined at a frequency high enough so at several different TE_{nm} or TM_{nm} modes can propagate, nd if the lossy wedge terminates each mode properly, en the wedge will generate noise power P_n separately each mode.

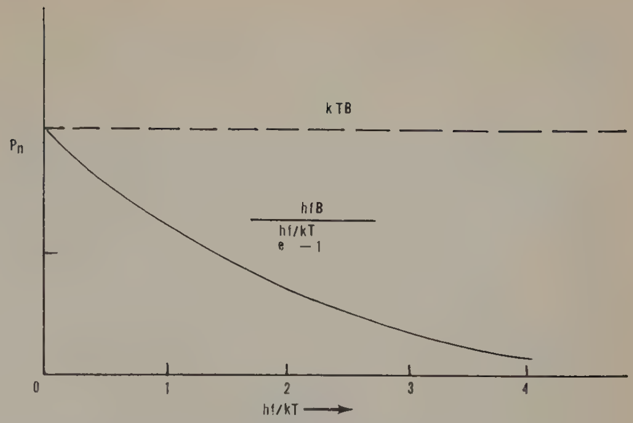


Figure 6 — The noise power P_n decreases below kTB at very high frequencies or very low temperatures.

Finally, if we assume that the exponent in Equation 3 is small, $hf/kT << 1$, then we can approximate Equation 3 as

$$P_n \approx kTB, \qquad hf/kT << 1 \qquad (4)$$

This approximation is valid for almost all normal microwave frequencies and temperatures. A convenient rule to remember is that

$$\frac{hf}{kT} \approx \frac{1}{20} \frac{f(\text{kMc/s})}{T(^\circ\text{K})} \qquad (5)$$

Thus, at 10 kMc/s a temperature $T = 1/2°K$ is required to make $hf/kT = 1$.

Figure 6 is a plot of the thermal noise power per unit bandwidth vs. frequency, as given by the exact expression of Equation 3. In view of the almost universal validity of the approximation of Equation 4, it has been remarked that we spend all of our lives right at the origin of the horizontal axis in Figure 6. However, as our technology pushes to higher frequencies and lower noise temperature devices, we are beginning to creep away from this origin.

Thermal Noise and Blackbody Radiation

We will now point out that thermal noise in resistors and transmission lines, and the blackbody radiation density inside any enclosure, are really one and the same thing. This comes about as follows. Consider a unit volume of empty space inside a large enclosure. There are a large number of different possible orthogonal traveling waves in the enclosure which pass through this volume. If we are talking about the inside of an enclosure which is entirely at temperature T, we can assume that each of these traveling waves can be traced back to a wall or a termination of some sort, somewhere inside the enclosure, at temperature T. Therefore, each traveling wave will be carrying noise power P_n as given by Equation 3. Also, each wave will have an energy density associated with it, given by its power divided by its group velocity. The total energy density at any point in the enclosure is the summation of the energy densities of all the noise waves passing through that point. This energy density is the *thermal blackbody radiation density* inside the enclosure. If the enclosure is large compared to a wavelength of the frequency of interest, the blackbody radiation density has a constant value, independent of position within the enclosure or of the size or shape or wall material of the

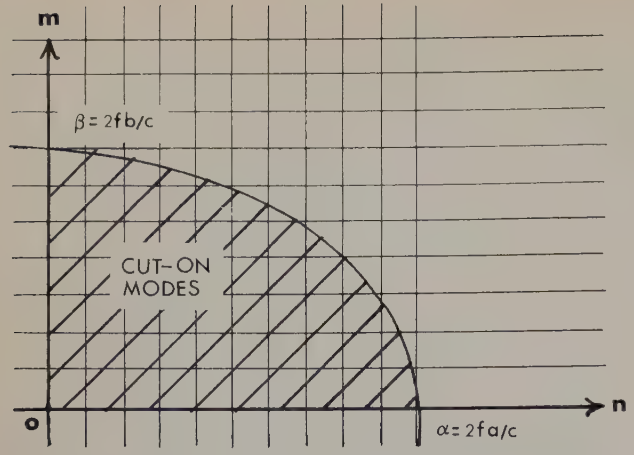


Figure 7—Values of nm inside the ellipse represent TE and TM modes which can propagate in rectangular waveguide at frequency f.

enclosure, and dependent only on frequency and temperature.

We will derive the general formula for the blackbody radiation density inside a large enclosure by using a convenient special case, namely an arbitrary length of rectangular waveguide, of width a and height b, which is perfectly terminated at both ends. The dimensions a and b are assumed to be very much greater than a wavelength at the frequency of interest, so that a great many higher-order TE_{nm} and TM_{nm} modes can propagate. Now, it is a theorem of microwave theory that the TE_{nm} and TM_{nm} modes of rectangular waveguide form a complete set, i.e., they are all the modes we need to completely describe the fields inside the guide. At a given frequency f, the set of TE and TM modes which can propagate consists of all the modes satisfying the 'cut-on' condition

$$\left(\frac{n\pi}{a}\right)^2 + \left(\frac{m\pi}{b}\right)^2 \leqslant \left(\frac{2\pi f}{c}\right)^2 \qquad (6)$$

or

$$\frac{n^2}{\alpha^2} + \frac{m^2}{\beta^2} \leqslant 1 \qquad (7)$$

where $\alpha = 2fa/c$ and $\beta = 2fb/c$ are convenient shorthand symbols. It can be noted that Equation 7 with the equals sign is the equation of an ellipse in the n,m plane, as shown in Figure 7. Any value of n and m lying inside the first quadrant of the ellipse represents a propagating TE or TM mode at the frequency f.

According to Equation 3 each nm mode is carrying noise power P_n down the waveguide. The stored energy per unit length associated with this mode is then P_n/v_g, where v_g is the group velocity of the mode. The stored energy per unit *volume* associated with the mode is obtained by dividing this by the volume of a unit length, which is ab. Thus, the noise energy density or noise energy per unit volume, ρ, associated with any one nm mode is P_n/abv_g. The total noise energy density is the summation of this over all possible modes. But, each possible nm value must actually be counted four times: twice to account for the TE and the TM waves with that index, and twice again because there are independent waves of power P_n in both directions along the guide.

Finally, account must be taken of the fact that the higher-order modes near the outer boundary of the nm ellipse are close to being cut-off, and as a result their group velocity is lower than the velocity of light c by a substantial factor. In fact, the formula for the group velocity of an nm mode at frequency f is

$$v_g = c[1 - (n/\alpha)^2 - (m/\beta)^2]^{1/2} \qquad (8)$$

When all of these factors are combined, the formula for the total noise energy density inside the waveguide is

$$P = \sum_{n,m} \frac{4}{ab\,c[1-(n/\alpha)^2-(m/\beta^2]^{1/2}} \; \frac{hfB}{\exp(hf/kT)-1} \qquad (9)$$

If the waveguide is large enough so that n and m run up to very large values, then this expression can with negligible error be converted from a double summation into a double integral:

$$\rho = \frac{4}{abc}\,\frac{hfB}{\exp(hf/kT)-1}\int_0^{\alpha} dn \int_0^{\beta\sqrt{1-(n/\alpha)^2}} dm \, \frac{1}{[1-(n/\alpha)^2-(m/\beta^2]^{1/2}}$$

$$= \frac{16hf^3B}{c^3}\,\frac{1}{\exp(hf/kT)-1}\int_0^{1} dx \int_0^{\sqrt{1-x^2}} dy \; (1-x^2-y^2)^{-1/2} \qquad (10)$$

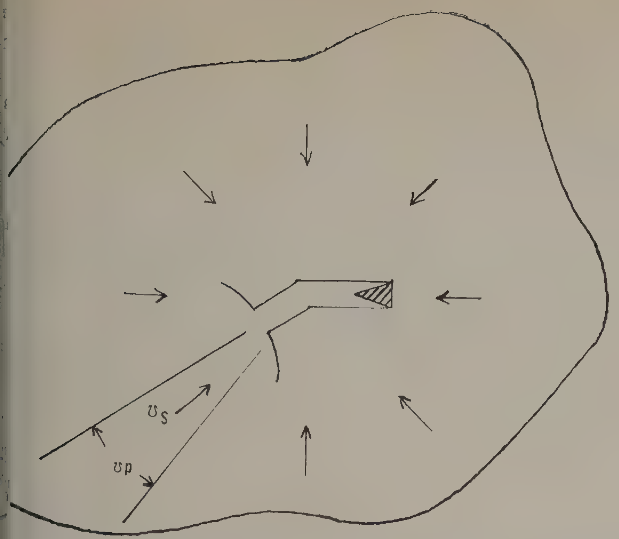
where the second line uses the substitutions $x = n/\alpha$ and $y = m/\beta$. Finally, by converting the x,y variables into polar coordinates, the double integral becomes the easily evaluated form

$$\rho = \frac{16hf^3B}{c^3}\,\frac{1}{\exp(hf/kT)-1}\int_0^{1} dr \int_0^{\pi/2} d\theta \; r(1-r^2)^{-1/2}$$

$$= \frac{8\pi hf^3B}{c^3}\,\frac{1}{\exp(hf/kT)-1} \qquad (11)$$

The final line is the standard expression for blackbody radiation density which can be found in any text on modern physics. It was first derived (in quite a different manner) by Planck.

The waveguide case considered here is rather special, but the result, Equation 11, is quite general. Johnson or Nyquist or thermal noise in an electrical circuit, and blackbody radiation in an enclosure, can both be derived from the same fundamental principle given in Equation 3 and are essentially the same thing. A classic example used to illustrate this identity is a matched transmission line connected to an antenna inside a large enclosure, the whole system being in thermal equilibrium at temperature T. The transmission-line termination generates thermal noise power P_n which is delivered to the antenna, radiated out into the enclosure, and absorbed by the walls. At the same time, the blackbody radiation density inside the enclosure means that noise radiation is present which is picked up by the antenna and delivered to the termination. Since the system is in thermal equilibrium, the two



ure 8 — An antenna and a terminated transmission line inside a large enclosure.

ocesses must just balance. Because of a general pro- rty of all antennas, we can show that this is indeed the e.

We consider a situation such as that shown in Figure 8. e first thing which must be found is the noise energy x falling upon the antenna, S_Ω, where we mean that dΩ is the noise power per unit area falling upon the tenna from the small range of directions dΩ. If the closure is large, S_Ω will be the same for every direction. nsider a point at the center of the antenna (or any- ere else, for that matter). The noise flux upon this nt from the range of directions dΩ is $S_\Omega d\Omega$. The ise energy density (per unit volume) associated with s flux must be $S_\Omega d\Omega/c$, since a free-space wave travels the velocity of light c. The total noise energy density the point is the summation of contributions from all ssible directions. But, this must be just the blackbody liation density ρ, so that we can write

$$\rho = \int (S_\Omega/c)d\Omega = 4\pi S_\Omega/c \qquad (12)$$

$$S_\Omega = (c/4\pi)\rho \qquad (13)$$

w, according to the definition of the effective aperture of an antenna, the amount of power received by the tenna due to a flux $S_\Omega d\Omega$ from direction (θ, φ) is

$$dP = \frac{1}{2} S_\Omega A_e(\theta, \phi)\ d\Omega \qquad (14)$$

ere $A_e(\theta, \phi)$ is the effective aperture in that particu- direction. The factor of $\frac{1}{2}$ enters because the noise rgy has random polarization and so only $\frac{1}{2}$ of the rgy is properly polarized to be received by the antenna. ing Equation 13, the total power received by the an- na becomes

$$P = \frac{c\rho}{8\pi}\int A_e(\theta,\phi)d\Omega \qquad (15)$$

t, it is a general property of all antennas that the ef- tive aperture integrated over all directions is just equal to λ^2. Therefore, the noise power received by the antenna becomes, with the aid of Equation 11,

$$P = \frac{hfB}{\exp(hf/kT) - 1} \qquad (16)$$

which is exactly the same as the noise power generated by the termination and radiated outward from the antenna. This result can also be found in "Microwave Radiometry," by Donald B. Harris, in the April 1960 issue of *the microwave journal.*

References on Thermal Noise

There have been, of course, many papers written on thermal noise. An important historical reference is a paper by Einstein who, in 1906, treated thermal fluctuations of changes in conductors using his theory of Brownian motion[5]. The formula $P_n = kTB$ was first found empirically by Johnson in 1928, when he measured the noise generation in resistances[7]. Nyquist explained Johnson's results in the same year by deriving the general form for thermal noise generation[8]. The pickup of blackbody radiation by an antenna inside an enclosure was analysed by Burgess in 1941[2]. All of these papers remain good reading even today. Many other tutorial articles and books cover the topics of this section, although the viewpoint and derivations given here differ from the standard ones[2,6,9,11].

NOISE WAVES IN LOSSY TRANSMISSION LINES

As a further development of the ideas developed in the previous section, let us consider noise generation in lossy transmission lines. We will consider in particular the problem of a line containing two different loss mechanisms which are at different temperatures. The technique of solving this problem is of interest, and in addition the answer is directly applicable to computing the noise figure of a traveling-wave maser amplifier.

Noise Power Flow and Noise Generation in a Lossy Line

Consider a length of lossy uniform transmission line having an attenuation coefficient α, so that the decrease of power in a wave with distance along the line is given by

$$dP/dz = -2\alpha P \qquad (17)$$

We will suppose that our lossy line is in thermal equilibrium at temperature T, and that it either extends indefinitely in both directions or else is terminated at both ends by matched terminations which are also at temperature T.

We first assert that if we make measurements at any point along the lossy line, we will find noise waves of noise power P_n traveling both to the right and to the left. This can be proven by imagining that the line is cut and a lossless section of line of the same characteristic impedance inserted. Then since the lossless section is perfectly terminated at both ends by the lossy line, there will be noise waves of power P_n running both ways in the lossless section. But this statement remains true for any arbitrary length of the noiseless section, even down to zero length.

Consider two arbitrary planes along the lossy line separated by a small length dz, as shown in Figure 9. The noise wave traveling to the right at the first plane carries

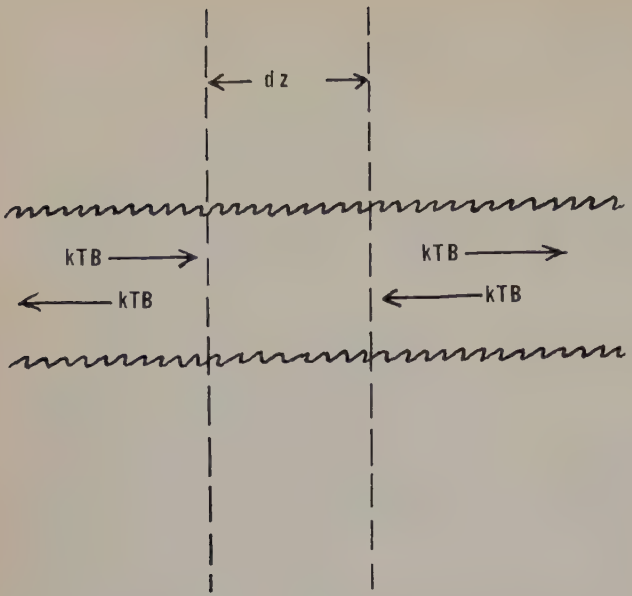


Figure 9 — In a lossy line at thermal equilibrium, the noise power flow at every plane is $P_n = kTB$.

power kTB (assuming $hf/kT << 1$ for simplicity). A fraction of this power will be absorbed by the loss in the line between the two planes according to the expression

$$dP_{abs} = 2\alpha P \ dz = 2\alpha kTB \ dz \qquad (18)$$

But, the noise power at the second plane will still be kTB. Therefore, the loss must also generate an equal amount of noise power, i.e.

$$dP_{gen} = 2\alpha kTB \ dz \qquad (19)$$

and must add this back into the noise wave. According to this picture, the noise power stays at kTB despite the line losses because the line losses generate an amount of power which at thermal equilibrium just matches the amount of power they absorb.

Note that the noise power kTB at one plane is not the same noise power kTB as was present at some earlier plane, in the sense that one could not transmit information for long distances down a lossy line by using a noise-like signal to carry the information. Note also that exactly the same noise absorption and generation process takes place for the noise waves traveling to the left as to the right.

One important consequence of Equation 19 is that if a signal is passed through a section of lossy transmission line, not only is the signal attenuated by the losses, but also a certain amount of noise is added to the signal by the thermal noise generation in the losses. We will derive an expression for this added noise. Consider a section of lossy transmission line extending from $z = 0$ to $z = l$, and suppose that power P_{in} is incident upon the $z = 0$ end of the line. This input power may itself be signal, noise, or a mixture of the two. Now, we argue that the power dP absorbed by the line loss in a small length dz is given in general by $2\alpha P \ dz$. Only in the special case of thermal equilibrium is this equal to $2\alpha kT \ dz$ as in Equation 18. On the other hand, the noise power generated by the loss in any small length dz is always $2\alpha kT \ dz$ as in Equation 19, regardless of the actual power P at that point, since the thermal noise generation ought to depend only on the temperature and not on the actual power flowing. Therefore, the wave traveling towards positive z in our lossy line will be governed by the differential equation.

$$\frac{dP}{dz} = -\frac{dP_{abs}}{dz} + \frac{dP_{gen}}{dz} = -2\alpha P + 2\alpha k \ TB \qquad (20)$$

Note that it is the uncorrelated nature of the thermal noise generated which permits us to deal with the power in this simple fashion, rather than having to consider voltages and currents and their relative phases as is usually necessary in transmission-line problems. Equation 20 can be integrated in straight-forward fashion. Applying the input boundary condition P_{in} gives for the power out at $z = l$ the result

$$P_{out} = e^{-2\alpha l} P_{in} + (1 - e^{-2\alpha l}) kTB \qquad (21)$$

This says that the power out of the line is the power into the line attenuated by the factor $e^{-2\alpha l}$, together with an added thermal noise power given by the second term on the righthand side. In Part III we will see that this added noise power due to insertion losses is a major practical limitation in achieving very-low-noise amplifier systems.

In practice, the case of small insertion losses, $2\alpha l << 1$, and $e^{-2\alpha l} \approx 1$, is often of interest. If we note that the insertion loss in db of the transmission-line section is given by $L_{db} = 10 \log_{10} e^{-2\alpha l} = 8.68 \alpha l$, then Equation 21 can be approximated by

$$P_{out} \approx P_{in} + (L_{db}/4.34) \ kTB, \ L_{db} < \frac{1}{2} \ db \qquad (22)$$

Thus, for small losses the signal is nearly unattenuated, but a finite amount of thermal noise is added to the signal by the losses.

A Line with Two Losses at Different Temperatures

We will now consider a transmission line such as that shown in Figure 10, which contains two different loss mechanisms α_1 and α_2 at temperatures T_1 and T_2, respectively. A physical example of this might be a waveguide with lossy walls which are at one temperature, filled with a lossy dielectric which is at another temperature. A more interesting example, we will see later, is a traveling-wave maser with a lossy slow-wave circuit. We consider a finite length l of such a line, as shown, and consider only the waves in one direction, say to the right. The in-

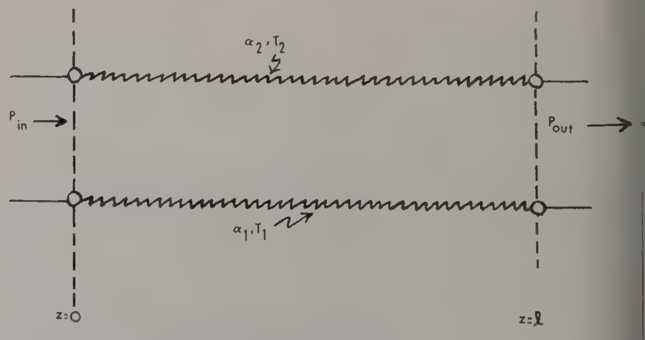


Figure 10 — A finite length of lossy line having two loss mechanisms at different temperatures.

dent power at the input end, either noise power or therwise, is P_{in}, and we seek the output power P_{out} at e other end. If the argument used for Equation 20 is alid, the power absorption and noise generation along the ne should be given by the expression

$$P/dz = -2(\alpha_1 + \alpha_2)\ P + 2k(\alpha_1 T_1 + \alpha_2 T_2)B \qquad (23)$$

gain solving and putting in the boundary condition P_{in}, e obtain for the output power the result

$$P_{out} = L\ P_{in} + (1 - L)k\left(\frac{\alpha_1}{\alpha_1 + \alpha_2} T_1 + \frac{\alpha_2}{\alpha_1 + \alpha_2} T_2\right)B \qquad (24)$$

here the quantity L is the total insertion loss of the line, e.

$$L = e^{-2(\alpha_1 + \alpha_2)l} \qquad (25)$$

s with Equation 21, we see that the output consists of e attenuated input, plus additional terms which represent the noise generated by the losses at their respective mperatures. Obviously, each temperature gets weighed cording to the fraction of the loss contributed by that ss mechanism. One reason for deriving this expression that we will be able to use it later in evaluating traveling-wave maser noise figures.

USEFUL NOISE THEOREM

We will now present a theorem which is very useful n finding the noise output of a complicated system of oisy elements. The theorem will be stated first in a mple form valid for reciprocal systems only, and then n a more general form applicable to nonreciprocal systems as well.

he Noise Theorem for Reciprocal Systems

Consider a system containing N different lossy elements, umbered i = 1, 2 . . . N, each lossy element i being at different temperature T_i. In addition, the system has an utput terminal or port which we can number i = 0. For mplicity, the output port is assumed to be matched, in e sense that a perfect match is seen looking back into e output port from the outside.

It is apparent that thermal noise power will be genered by each of the lossy elements i and sent into the stem. Some of the thermal noise power from each lossy ement may emerge from the output port. Let the total nerging noise power be P_n, and let it be related to an fective noise temperature for the network by the equaon

$$P_n = kT_{eff}B \qquad (26)$$

he question we ask is: how is this effective thermal oise temperature of the output port related to the inrnal lossy elements of the system and to their temperaures?

This question is answered by the noise theorem as ollows. Suppose that a unit amount of power in the me frequency band B is sent back into the system rough the matched output port. Since the output port is matched looking in, all of this power will go to the internal losses. A fraction p_i of the power will go to each lossy element, with

$$\sum_{i=1}^{N} p_i = 1 \qquad (27)$$

Then, the theorem we are interested in says that the effective noise temperature for a reciprocal system is given by

$$T_{eff} = \frac{\sum_{i=1}^{N} p_i T_i}{\sum_{i=1}^{N} p_i} = \sum_{i=1}^{N} p_i T_i \qquad (28)$$

In other words, the effective noise output of the system is the noise contribution of each lossy element in the system weighted by a factor consisting of the amount of power received by that element when unit power is sent back into the system.

A Practical Example

A simple example will show how the theorem can be used. Consider an antenna pointing skyward, perhaps to receive signals from a space vehicle or a radio astronomy source against a cold background of intergalactic noise. Besides the background noise, there are other sources of noise in the antenna system, in general at different temperatures, including losses in the atmosphere through which the signals must travel, ohmic losses in the antenna, losses in the antenna feed lines, and pickup from the ground via the side and back lobes of the antenna pattern. A question of considerable importance then is, what is the total noise output from the antenna terminals to a receiver?

The antenna system is a reciprocal system, in which each of the noise sources just mentioned can be considered as a lossy element. The intergalactic background can be regarded as a lossy element also, inasmuch as any power radiated out into it never returns. The effective temperature of the antenna in reception can be determined by supposing that unit power is sent into the antenna terminals and then asking how much of the power is absorbed by each of the sources mentioned. The weighting factors p_i can be calculated using knowledge of the antenna and feed line losses, the atmospheric attenuation, and so on. The effective antenna temperature is then given by Equation 28.

The Noise Theorem for Nonreciprocal Networks

Discussion of the noise theorem for the nonreciprocal case requires going into a bit more detail. As an analytical

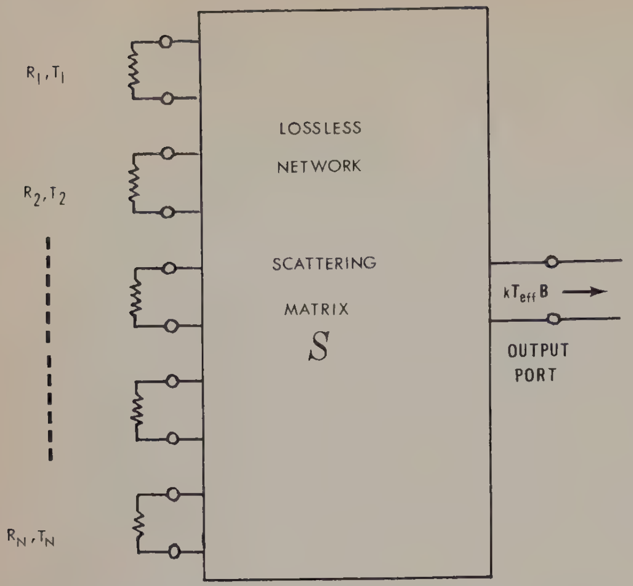


Figure 11 — Analytical model of a system (possibly nonreciprocal) containing N different lossy elements.

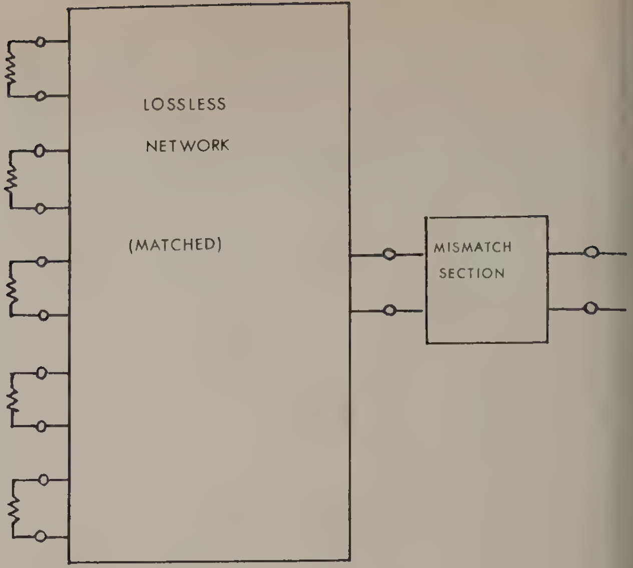


Figure 12 — A mismatched network separated into a matched portion plus a lossless mismatching section.

model of our general system, we can consider a series of resistances or terminations R_i representing the lossy elements, joined together by a lossless but possibly nonreciprocal network, as shown in Figure 11. The network may contain ideal circulators or nonreciprocal phase shifters but not ideal isolators, since every isolator must contain loss. However, an ideal isolator can be separated into an ideal circulator plus a termination, as we will show later. The termination can then be added to the set of R_i's. We also note that if the network is not matched looking into its output port, we must separate it into a matched portion plus a lossless mismatch, as shown in Figure 12. The noise theorem can be applied to the matched portion, after which the effect of the mismatch can be accounted for in a separate calculation.

The behavior of a multi-port network such as in Figure 11 can be described readily by using the scattering matrix approach, which we will briefly summarize. Suppose for conceptual purposes that a short length of transmission line of the proper characteristic impedance $Z_{oi} = R_i$ is inserted between each termination R_i and the network. The amplitude of a wave traveling inward from termination R_i to port i of the network will be denoted by a_i, while the corresponding outgoing wave will be b_i. The wave amplitudes are normalized such that the power flowing in each direction is $|a_i|^2$ and $|b_i|^2$, respectively. If the transmission line has a voltage V_i defined in the usual sense, then a_i or b_i are equivalent to $V_i/(2Z_{oi})^{1/2}$.

The terminal behavior of the multi-port network is described by the incoming and outgoing waves a_i and b_i and the scattering coefficients S_{ij} which relate them. In general, an ingoing wave a_j in the jth port will create outgoing waves in all the other ports. In particular, the outgoing wave b_i in line i caused by the ingoing wave a_j in line j will be given by

$$b_i = S_{ij} a_j \tag{29}$$

The total outgoing wave in line i due to the incoming waves in all the other lines can be written as

$$b_i = \sum_{j=0}^{N} S_{ij} a_j \tag{30}$$

This equation is actually a set of N + 1 equations, one for each possible value of i. The entire set is sometimes written in matrix form as

$$b = Sa \tag{31}$$

where b and a are column vectors with elements b_i and a_i, and S is a square matrix, the *scattering matrix,* with elements S_{ij}.

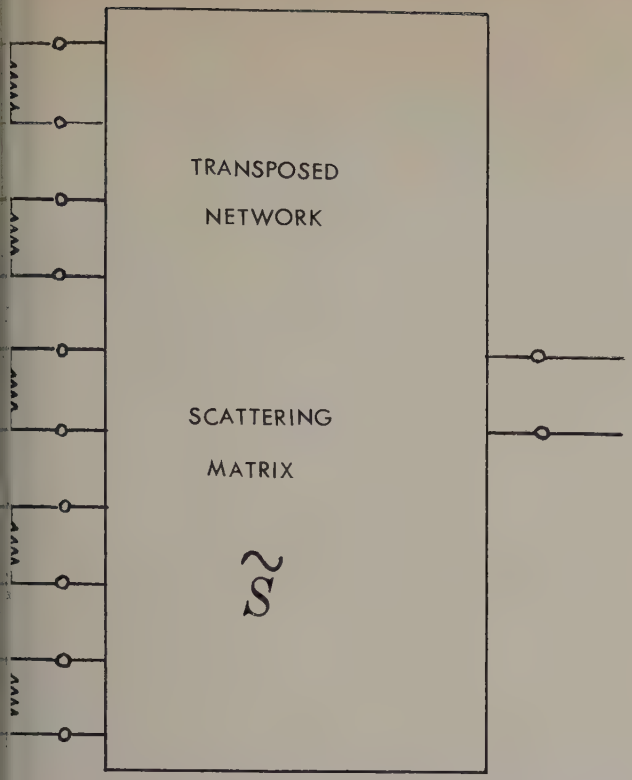
We must now consider the new scattering matrix which can be formed by putting the ijth element of our original scattering matrix into the jith position of the new matrix.

This new matrix is called the *transpose* $\tilde{S}$ of the original scattering matrix. The elements of the original and transpose matrices are related by

$$\tilde{S}_{ij} = S_{ji} \tag{32}$$

We must also consider a new hypothetical network called the *transposed network.* This is a network whose scattering matrix would be the transpose $\tilde{S}$ of the scattering matrix S of the original network. We will see shortly what this means physically. Figure 13 shows a transposed network.

We suppose that exactly the same terminations R_i are attached to the transposed network as to the original network. Then it is quite easy to show, although we will not go through the details here, that the noise theorem becomes the following: The effective noise temperature of the output port of the *original* network is the weighted average of the noise temperatures of the terminations R_i, but the weighing factors must be obtained by sending unit power into the matched output port of the *transposed* network and seeing what fraction $\tilde{p}_i$ reaches each ter-



igure 13 — Transposed network corresponding to the original network of Figure 11.

ination. In other words, the effective noise temperature f the original network is given by

$$T_{eff} = \sum_{i=1}^{N} \tilde{p}_i T_i \qquad (33)$$

here the $\tilde{p}_i$ are obtained from the transposed network. In fact, $\tilde{p}_i$ is equal to $|S_{io}|^2$).

eaning of the Transposed Network

If the network under discussion is entirely reciprocal, en it can be shown that the original and transposed netorks are physically identical. Therefore, $\tilde{p}_i = p_i$ and the oise theorem reduces to the simpler form given earlier. he meaning of the noise theorem and of the transposed etwork in a nonreciprocal network is perhaps best undertood by considering an example, for instance the ideal irculator shown in Figure 14a. The scattering matrix of uch a circulator has the form

$$S = \begin{bmatrix} 0 & 0 & 0 & 1 \\ 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix} \qquad (34)$$

he transpose of this scattering matrix is

$$\tilde{S} = \begin{bmatrix} 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 1 & 0 & 0 & 0 \end{bmatrix} \qquad (35)$$

nspection will show that this is the scattering matrix of the circulator shown in Figure 14b, which circulates in the opposite direction. In other words, the transpose of a circulator is simply another circulator, but one which circulates in the opposite sense.

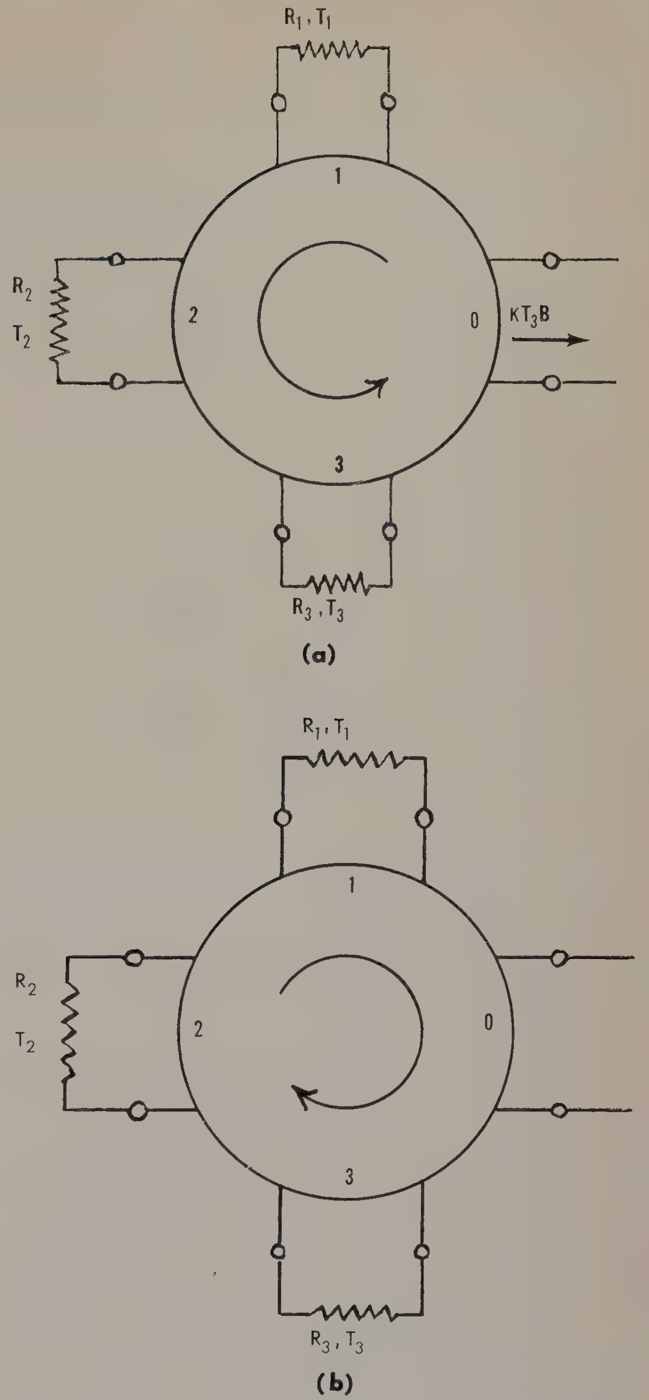


Figure 14 — (a) A four-port circulator; (b) The transpose of a circulator is another circulator in the opposite sense.

Let us apply the noise theorem to this example. It is obvious physically that the thermal noise emerging from port 0 of the original circulator all originates in termination R_3, so that the effective temperature is $T_{eff} = T_3$. But, the weighting factors if unit power is sent into this circulator are clearly $p_1 = 1$, $p_2 = p_3 = 0$, which will not give the right answer. On the other hand, if unit power is sent into the transposed circulator the weighting factors are $\tilde{p}_3 = 1$, $\tilde{p}_1 = \tilde{p}_2 = 0$, which does give the right an-

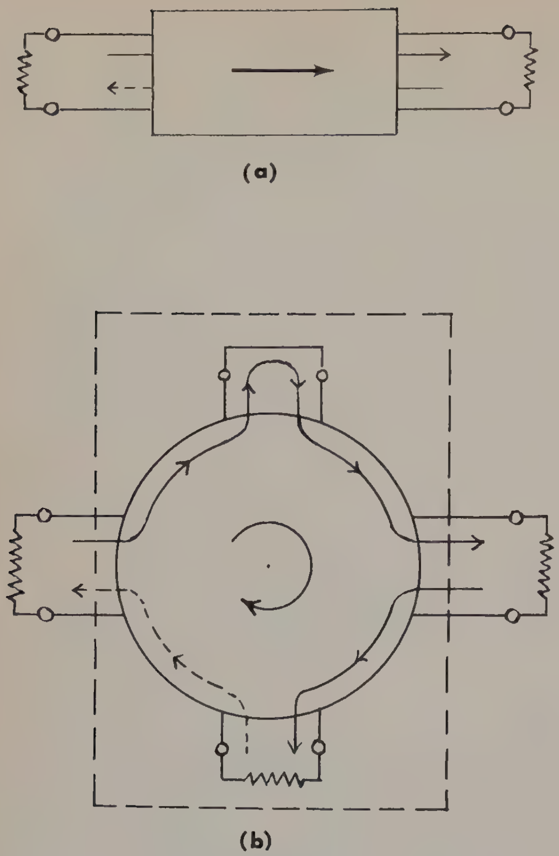


Figure 15 — (a) An ideal isolator; (b) resolved into an ideal circulator plus a termination.

swer. Hence, the noise theorem works, at least for this example.

Noise in an Ideal Isolator

An ideal isolator is a nonreciprocal device which transmits without attenuation in the forward direction and absorbs completely all power in the reverse direction, as shown in Figure 15a. One is sometimes presented with the following paradox involving an isolator. Suppose that matched terminations are connected to both ends of the isolator in the figure, with the righthand termination being colder. Then the noise power from the cold termination is transmitted to the hot termination, but the noise power from the hot termination cannot reach the cold termination. Net energy is apparently being transferred from a colder body to a hotter body, in violation of the second law of thermodynamics.

This paradox is readily resolved by noting that an isolator can be separated into the elements shown in Figure 15b, i.e., a circulator, a termination, and a short circuit. The accounting of energy flows is not complete without considering the temperature and noise power of the internal termination. If one considers the noise power exchange between all three terminations, one finds that the total entropy of the system always increases, regardless of the relative temperatures of the three terminations, and hence the second law is obeyed.

References and Comments

The noise theorem as given here can be found in a paper on masers by P. N. Butcher[4]. A similar but somewhat less satisfactory theorem has also been given by Strum[10]. Essentially the same noise theorem can also be found in an unpublished Hycon Eastern report[3], but with an interesting variation. Instead of considering the transpose of a network, the report assumes that all of the nonreciprocal elements in the network will be magnetic in nature. It is then stated that the dc magnetic fields of all the nonreciprocal elements must be reversed before computing the weighting factors p_i. This is an interesting statement, since it reinforces one's intuitive feeling that every nonreciprocal device must require some sort of dc field, either magnetic or electric, in order to establish a reference direction or significant direction in space. In fact, all practical nonreciprocal passive microwave devices do use a dc magnetic field. Reversing this dc magnetic field transposes the scattering matrix of the device, e.g. makes a circulator circulate in the opposite direction.

It would seem that various quasi-passive electron-beam devices, e.g. a klystron with unity gain, or a Kompfner dip coupler, ought also to be turned into their transposes in some similar fashion, perhaps by reversing the direction of travel of the electron beam. This might be a useful way to gain insight into the noise behavior of microwave beam-type electron tubes.

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Part II of Professor Siegman's paper will appear in the April issue of *the microwave journal.*

ATMOSPHERIC ABSORPTION OF 10-400 KMCPS RADIATION:

Summary and Bibliography to 1961

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ITRODUCTION

Interest in the upper-microwave and millimeter spec- um has increased rapidly in the past few years because the importance of this region of the spectrum to sci- ce, to the military and to industry. In many applications, mospheric absorption is a limiting factor in receiving gnals in this part of the electromagnetic spectrum; in her applications it can provide security of information, d in still others it can provide a means of obtaining formation of scientific or practical interest.

Research in this field has been conducted for several cades, but the theory cannot yet account accurately for e attenuation throughout the spectrum, and experi- ents, for many reasons, have covered the spectrum and mospheric conditions only spottily. Nature refuses to operate in this effort and forces us to contend with an mosphere which varies widely in composition, pressure d temperature, is extremely turbulent and often in- udes water in "unpleasant" forms such as clouds, snow d rain.

This report attempts to summarize the presently avail- le data on atmospheric absorption and to explain the nitations of these data. Emphasis is placed herein on sorption by normal molecular oxygen and water vapor; her contributing factors are considered only incidental- if at all. Some of these factors are: isotopic effects, sorption by atoms and other molecules, turbulence and nomogeneities, emission radiation by atmosphere, ttering by air or land, clouds, rain, snow, dust, etc., nospheric absorption and scattering, interactions other an molecular collisions, and refraction effects.

The bibliography, too, reflects this selectivity. It pur- rts to cover all directly pertinent published experiment- data, but attempts to be only representative in erences to the theory and neglects many associated eoretical considerations which are pertinent in develop- g the theory. A good introduction and more complete erences can be found in various texts, such as the ok by Townes and Schawlow, (1955).

In an appendix are given some pertinent atmospheric data and a reminder of some of the characteristics of the attenuation curves.

SUMMARY OF DATA

General

For microwave and millimeter wave transmission wholly or partially within the earth's atmosphere, the main sources of signal attenuation are water vapor and molecular oxygen. In both cases, absorption is caused by molecular transitions which have been analyzed by many theorists; the form presented by Van Vleck (1947), using the Van Vleck-Weisskopf (1945) equation, has accounted most closely for observed absorption data.

The Van Vleck-Weisskopf (VVW) equation contains two sets of parameters. The first determines the frequency of each absorption line and is obtained either from a knowledge of the energy levels involved or by measurement. The second determines the widths of the absorption maxima and is best found by measurement.

The frequencies of the principal absorption maxima have been found quite accurately by several experimenters and correspond quite well to the energy levels determined theoretically for both water vapor and oxygen. There is a possible water vapor absorption near 110 kMcps which is not yet predicted by the theory, and indications of absorption by rarer gas such as N_2O, NO_2, SO_2 and O_3 in the 100-106 kMcps region.

Quantitative prediction of the absorption, particularly in the "wings" of the maxima, has been far less successful. Most attempts to adapt the VVW equation to observed absorption measurements use a single line broadening constant throughout the absorption spectrum of oxygen and another for water vapor, despite experimental and theoretical evidence to the contrary [Benedict and Caplan (1959)], because of scarcity of information about the exact parameters to use. Furthermore, this equation considers only the broadening effect of collisions between molecules. Neglected are Doppler, saturation and collision broadening, which have been discussed by

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Operated with support from the U.S. Army, Navy and Air Force.

T. F. Rogers [AFCRC (1951), unpublished]. The equation is also known to break down somewhere in the infrared.

For atmospheric absorption except at high altitudes, the pressure is high enough to cause line widths to be of the order of magnitude of their separation and even of their center frequency. Under these conditions, the absorption calculated at any frequency that does not coincide with a strong absorption maximum is influenced appreciably by the wings of many lines and can vary widely depending on the broadening assumed for each of them. This is discussed further below for each constituent.

Oxygen

There are some tens of molecular interactions which give rise to absorptions grouped around 5 mm; there is another at 2.5 mm. At atmospheric pressure, the 5 mm lines broaden enough so that they nearly form a single line. Various estimates have been made of a single broadening parameter which can best approximate the observed line shape, [T. F. Rogers, AFCRC unpublished, whose results are reproduced in several references, such as Crawford and Hogg (1956)]. Measurements made in the laboratory near 5 mm [Artman and Gordon (1954)] give a constant larger than that which best fits atmospheric propagation measurements [Crawford and Hogg (1956); Straiton and Tolbert, (1960)]. Neither value gives a curve which exactly follows the somewhat uneven peak of this line. There is a similar difference between recent laboratory measurements [Anderson, Johnson and Gordy (1953)] and atmospheric measurements near 2.5 mm. Besides this resonant absorption there is also a continuous nonresonant or Debye absorption.

Water Vapor

There are water vapor maxima near 1.35 cm, 1.63 mm and at some 600 frequencies [Ghosh and Edwards (1956)] in the submillimeter region. Contrary to the situation with oxygen, propagation measurements near either of the two lowest lines are not accounted for by a single line width parameter. At higher frequencies there has been only fair success in combining the contributions of the many submillimeter lines to predict with any accuracy the absorption at any point in the wings of the various maxima.

Atmospheric Propagation: Horizontal

Once measurements are made of atmospheric attenuation under given conditions, it becomes necessary to convert these to some standard conditions for comparison with other data. Normally, data are taken at several values of water vapor density, (assumed hopefully to be constant in time and space during a run), plotted against this density and extrapolated linearly (which may not be a good assumption) to zero water pressure; the residual loss is assumed to be due to oxygen. The oxygen and water vapor losses are then adjusted independently to standard conditions using the VVW equation and then added to give a data point. Aside from experimental difficulties, discussed for example by Straiton (1960), this procedure depends on most of the theoretical problems discussed above.

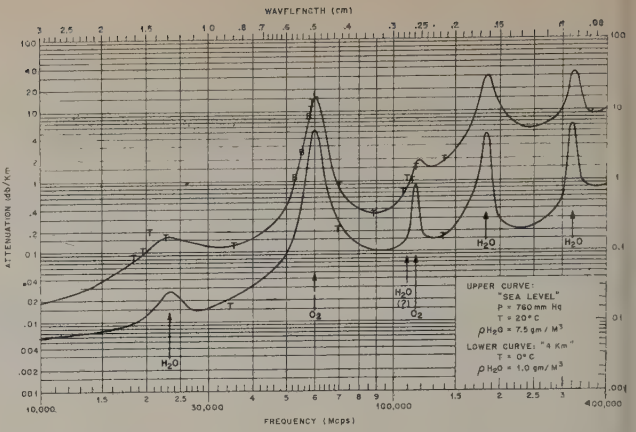

Figure 1 — Attenuation per kilometer for horizontal propagation.

Figure 1 was plotted by Straiton's group to give the best fit to data taken approximately as above, at two altitudes, using single line-width constants for water vapor and oxygen. Some points, representative of data taken by Lamont (L) and by the Texas (T) and Bell (B) groups, are included for comparison. It should be noted that apparent differences between experimental points and theoretical curves are minimized by the log-log scale used. However, agreement is quite good except for the regions near 20 kMcps and 110 kMcps. It may be quite difficult in practice to predict actual losses from these curves because of atmospheric inhomogeneities, precipitation, refraction effects and other sources of loss not considered. Particular caution should be employed in using the curves at frequencies above 140 kMcps, because of the uncertainties involved in their derivation and the lack of experimental verification.

The two "standard" conditions used are those selected by the Texas group. As a guide, a water vapor density of 7.5 gm/m³ at 20°C corresponds to a partial pressure of 7.6 mm Hg. (One per cent of standard atmospheric pressure) or a relative humidity of about 43 per cent under these conditions.

Several of the references, particularly the Handbook of Geophysics (1960), discuss the effects of precipitation, but this will not be summarized here except to note that the absorption during a rainfall can be many-fold greater than during clear weather.

Atmospheric Propagation: Into Space

Experimental determinations of absorption through the entire atmosphere have typically used radiometers to measure signals received either from thermal sources in the atmosphere or from extraterrestrial sources such as the sun.

Using these data to predict attenuation under other conditions suffers not only from the difficulties outlined in the previous section, but also from several others. The spectral characteristics of the emitting source must be assumed or determined separately. The composition and other properties of the atmosphere as a function of altitude must likewise be assumed or measured. The separation of the absorption into water vapor and oxygen components then depends on these factors, whose effects depend in turn on the details of the theory used.

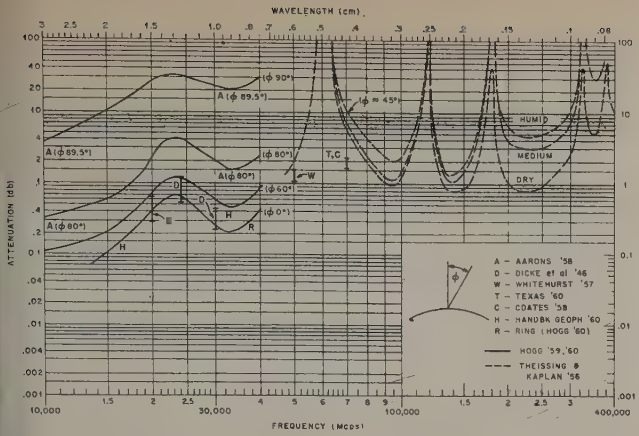

Figure 2 — Total attenuation for one-way transmission through the atmosphere.

Figure 2 summarizes the available experimental data and theoretical predictions. The points marked H were computed using a "standard maritime polar atmosphere" to 20 km altitude. Hogg's curves use a different atmospheric model and the VVW equation with parameters adjusted to fit the curve for transmission to the zenith ($\phi = 0$). Theissing's curves use actual temperature, pressure and water vapor measurements. The source in his experiments was the sun, and the detector was sensitive to an extended spectral range covering the sun's spectrum, which peaks at about 1.1 mm. His curves were computed by integrating the VVW equation over this spectrum as well as the other parameters discussed above. Since there is considerable doubt as to the validity of the VVW equation in this region of the spectrum and since the resulting curves for *total* absorption at an angle of about 45° with the zenith fall below measured sea level absorption *per kilometer* (cf. Figure 1, especially 2.15 mm data), the care necessary in using these curves is obvious.

Figure 3 in Appendix B partially describes a model atmosphere developed by the ARDC. Other properties of this atmosphere are given in the Handbook of Geophysics, (1960). In Figure 4 the water vapor content of this model is compared with Hogg's model and some representative measurements. It will be seen that the atmospheric water vapor content does not lend itself well to theoretical treatment. Figure 5 gives some pertinent water vapor properties.

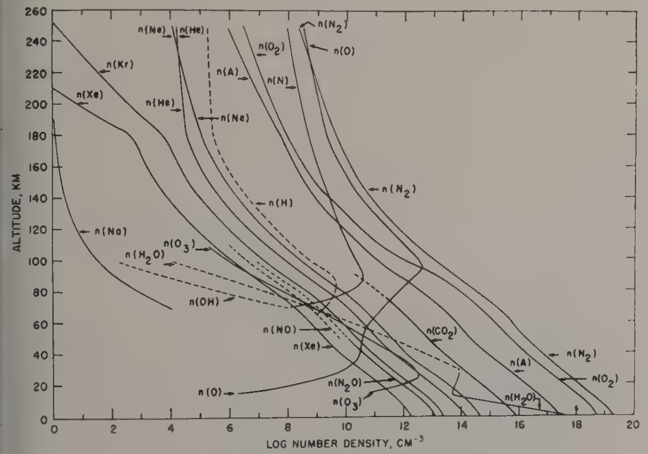

Figure 3 — Vertical distribution of atmospheric constituents. *From Handbook of Geophys., (1960), Figure 8.2. Diagram Courtesy of Geophysics Research Directorate, Air Force Cambridge Research Laboratories.*

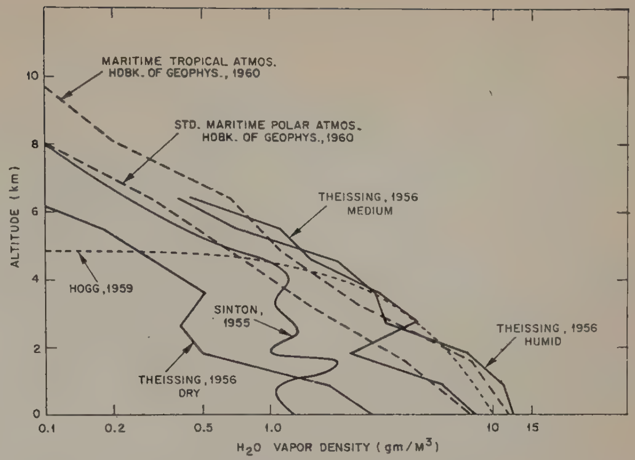

Figure 4 — Vertical distribution of atmospheric water vapor.

Figure 3 indicates that effective atmospheric thickness is much less for water vapor than for oxygen. This suggests, and is borne out by examination of Figure 1, that oxygen absorption affects transmission vertically through the atmosphere relatively more than it does horizontally at sea level. Also, line widths for vertical transmission should be somewhat narrower than for horizontal sea level transmission, being weighted in favor of lower densities. Therefore it may not be too inaccurate to assume an absorption spectrum, for vertical transmission through the atmosphere from sea level, of a shape similar to the lower curve in Figure 1, with ordinates multiplied by 8 to 10; (see Appendix A for a brief mathematical justification of this procedure.) The Handbook of Geophysics (1960) includes a detailed procedure for estimating the attenuation along any path within or through the atmosphere, taking precipitation and clouds into account. French et. al. (1959) gives a good review of the subject, including many of the factors not considered in this report.

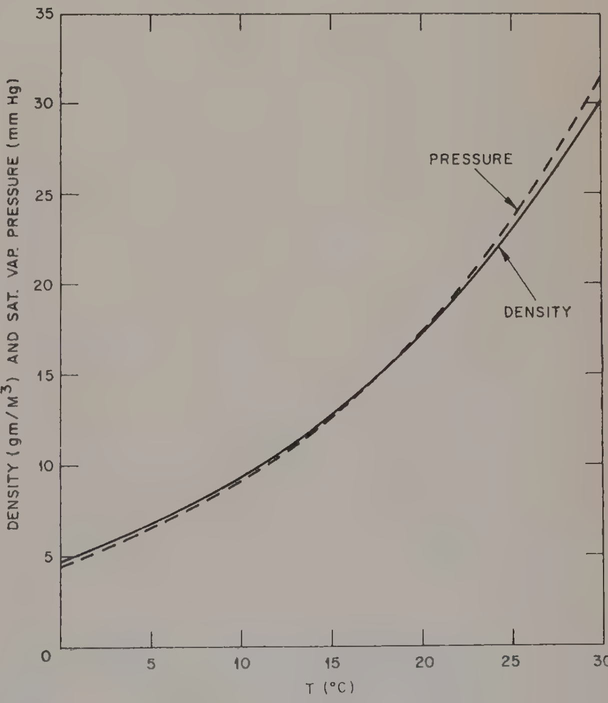

Figure 5 — Pressure and density saturated H_2O vapor vs. temperature.

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APPENDIX

A. Exponential Decay

The following notes may be useful when interpreting or using Figures 1 and 2. Consider two signals of original intensities P_{01} and P_{02}, traveling through media of attenuation constants a_1 and a_2 so that their intensities are P_1 and P_2 at distances x_1 and x_2. Then:

$$\frac{P_1}{P_{01}} = 10^{-a_1x_1/10}$$

$$\frac{P_2}{P_{02}} = 10^{-a_2x_2/10} = 10^{-(a_1x_1/10)(a_2x_2/a_1x_1)}$$

$$= \left(\frac{P_1}{P_{01}}\right)^{a_2x_2/a_1x_1}$$

There are three cases of particular interest here:

(1) At the same distance: $(x_2 = x_1)$

$$\frac{P_2}{P_{02}} = \left(\frac{P_1}{P_{01}}\right)^{a_2/a_1}$$

(2) If $a_2 = a_1$:

$$\frac{P_2}{P_{02}} = \left(\frac{P_1}{P_{01}}\right)^{x_2/x_1}$$

(3) At the same relative power:

$$\frac{P_2}{P_{02}} = \frac{P_1}{P_{01}}, \text{ so that } \frac{a_2x_2}{a_1x_1} = 1, \text{ or}$$

$$\frac{x_1}{x_2} = \frac{a_2}{a_1}$$

Now, a constant value of a_2/a_1 corresponds to a constant vertical linear distance between two curves on a plot such as Figure 1. Also, a constant value of x_2/x_1 for $a_2 = a_1$ corresponds to a constant vertical distance between two curves on a plot such as Figure 2. Thus, from the equations above, two parallel curves can represent a constant relative attenuation in two media, or the attenuation for a constant ratio of distances in the same medium.

B. Some Atmospheric Parameters
(See Figures 3, 4, 5.)

ACKNOWLEDGMENTS

Most of the references prior to 1955 were obtained from the book by Townes and Schawlow (1955); the bibliography follows their format. Figure 1 and much of the other data and analyses were taken from reports and publications by A. W. Straiton's group at the Electrical Engineering Research Laboratory, The University of Texas. The author has benefited from information given by T. F. Rogers, and from conversations with J. W. Meyer, G. S. Heller, P. E. Tannenwald and J. B. Resnick, all of Lincoln Laboratory.

A CIRCULARLY POLARIZED SLOT ANTENNA

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Introduction

Because of its broad pattern coverage and ability to be flush mounted, the linearly polarized slot antenna has been extensively used in missile and aircraft applications. When circular polarization is desired the rectangular aperture must be made square or circular in order to support the necessary orthogonal mode. The broad pattern coverage of the rectangular slot in the plane parallel to its narrow dimension is, therefore, sacrificed. In addition, a 90° phase shifter and 2:1 power divider must be added to the feed system, thus increasing the complexity of the antenna. This paper discusses an antenna design which allows circular polarization to be realized in a rectangular slot by the simple process of placing a tilted parasitic dipole in the plane of the aperture. A theory of operation is presented along with experimental results on a dipole-slot antenna. Axial ratios less than 1 db have been achieved at a single frequency, and axial ratios less than 3 db with a VSWR less than 1.8 to 1 have been realized over a 20 per cent band.

Theory of Operation

The following theory is intended to illustrate in a semi-quantitative way the principal of operation of the slot-dipole antenna. Consider the slot antenna of Figure 1 excited in the absence of the dipole such as to have a field $E_0 \cos \frac{\pi x}{a}$ across its aperture. If we now place a half wave parasitic dipole in the center of the aperture and assume the induced current to be cosinusoidally distributed, then the open circuit voltage at the dipole terminals is given by:⁽¹⁾

$$V_{o.c} = \int_{-\lambda/4}^{\lambda/4} E_l \cos \frac{2\pi l}{\lambda} \, dl$$

where E_l is the component of the slot aperture field parallel to the dipole. From Figure 1:

$$E_l = E_0 \sin\psi \cos\frac{\pi x}{a} = E_0 \sin\psi \cos\left(\frac{\pi l}{a}\cos\psi\right)$$

and

$$V_{o.c} = E_0 \sin\psi \int_{-\lambda/4}^{\lambda/4} \cos \frac{2\pi l}{\lambda} \cos\left(\frac{\pi l}{a}\cos\psi\right) dl$$

$$= \frac{\lambda E_0 \sin\psi \cos\left(\frac{\pi\lambda}{4a}\cos\psi\right)}{\pi\left(1 - \left(\frac{\lambda}{2a}\right)^2 \cos^2\psi\right)} \qquad (1)$$

The current flowing in the dipole is then:

$$I_0 = \frac{V_{o.c}}{R_0 + jx_0} = \frac{\lambda E_0 \sin\psi \cos\left(\frac{\pi\lambda}{4a}\cos\psi\right)}{\pi\left(1 - \left(\frac{\lambda}{2a}\right)^2\cos^2\psi\right)\left(R_0 + jx_0\right)} \qquad (2)$$

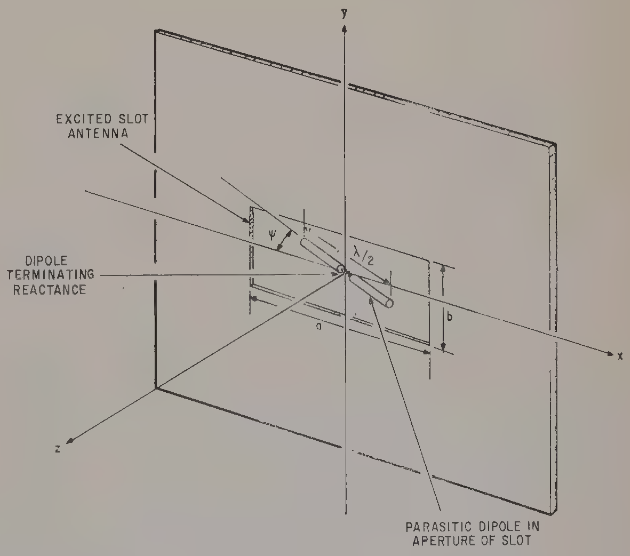
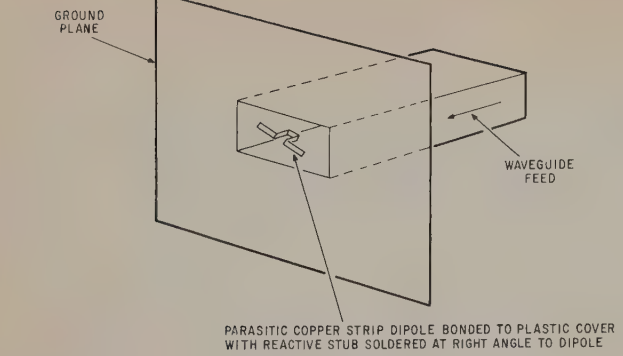
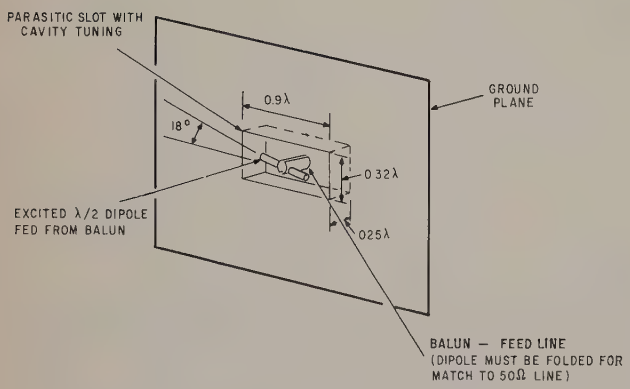

y
EXCITED SLOT ANTENNA
ψ
λ/2
DIPOLE TERMINATING REACTANCE
b
a
x
z
PARASITIC DIPOLE IN APERTURE OF SLOT

Figure 1 — Slot-dipole antenna configuration.


GROUND PLANE
WAVEGUIDE FEED
PARASITIC COPPER STRIP DIPOLE BONDED TO PLASTIC COVER WITH REACTIVE STUB SOLDERED AT RIGHT ANGLE TO DIPOLE

(a) SLOT EXCITED DIPOLE


PARASITIC SLOT WITH CAVITY TUNING
0.9λ
18°
GROUND PLANE
0.32λ
EXCITED λ/2 DIPOLE FED FROM BALUN
0.25λ
BALUN — FEED LINE (DIPOLE MUST BE FOLDED FOR MATCH TO 50Ω LINE)

(b) DIPOLE EXCITED SLOT

Figure 2 — Two physically realizable slot-dipole antennas.

where R_o is the dipole resistance as would be measured in the presence of the slot. Mutual coupling to images in the metallic boundary walls of the slot drops the free space value for R_o from 70 ohms to a value in the range 10-20 ohms (See Figure 6). x_o is the reactance of the dipole when located within the slot plus any external reactance that might be connected across the terminals of the dipole. As will be seen later x_o is used as a parameter to adjust the slot dipole system for circular polarization.

At a point on the axis normal to the slot the radiation field component due to the slot aperture field may be expressed as: (2)

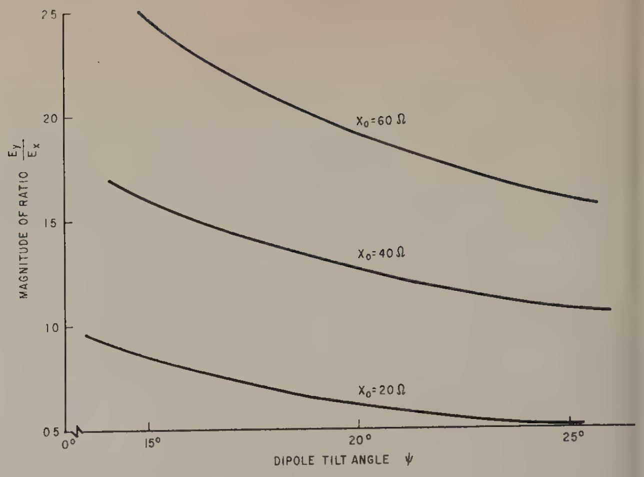


Figure 3 — Theoretical magnitude of ratio of orthogonal axial fields of slot dipole antenna.

$$E_{y_s} = \frac{j b E_o}{\lambda} \int_{-a/2}^{+a/2} \cos \frac{nx}{a}\, dx$$

$$= j \frac{2ab}{\pi\lambda} E_o \tag{3}$$

At the same point on the axis normal to the slot the reradiated field of the dipole is given by: (3)

$$E_{y_d} = \frac{-j\eta I_o}{2\pi} \sin\psi$$

$$E_{x_d} = \frac{j\eta I_o}{2\pi} \cos\psi \tag{4}$$

The minus sign follows from the necessary reversal of phase of the reradiated field of the dipole relative to the incident field of the slot in order to satisfy the zero tangential E field boundary condition at the surface of the dipole. Combining equations 2, 3, and 4 gives the ratio of vertical to horizontal field components along the axis normal to the slot aperture.

$$\frac{E_y}{E_x} = \frac{\dfrac{2ab}{\pi\lambda} - \dfrac{\eta}{2\pi}\sin\psi \left[\dfrac{\lambda \sin\psi \cos\left(\dfrac{\pi\lambda}{4a}\cos\psi\right)}{\pi\left(1-\left(\dfrac{\lambda}{2a}\right)^2 \cos^2\psi\right)\left(R_o + jx_o\right)} \right]}{\dfrac{\eta}{2\pi}\cos\psi \left[\dfrac{\lambda \sin\psi \cos\left(\dfrac{\pi\lambda}{4a}\cos\psi\right)}{\pi\left(1-\left(\dfrac{\lambda}{2a}\right)^2 \cos^2\psi\right)\left(R_o + jx_o\right)} \right]} \tag{5}$$

Equation 5 can be reduced to a magnitude and phase angle of the form:

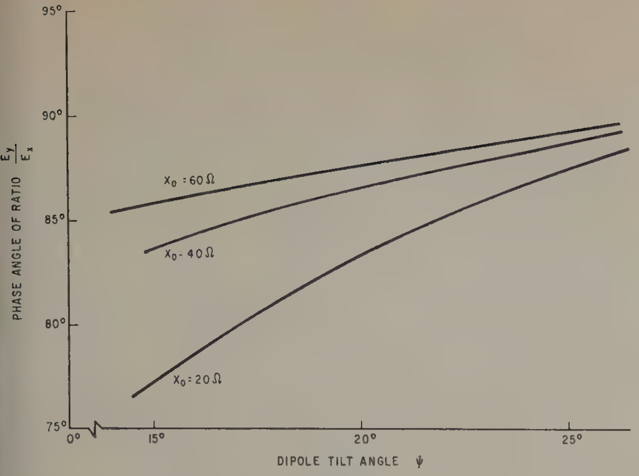


Figure 4 — Theoretical phase angle between orthogonal axial fields of slot dipole antenna.

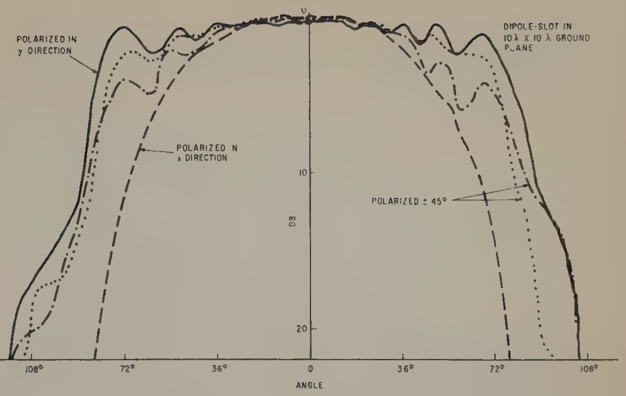


Figure 5(b) — Patterns in plane parallel to short dimension of slot for antenna of Figure 2(b). (YZ plane of Figure 1.)

$$\left|\frac{Ey}{Ex}\right| = \frac{\left(1-\left(\frac{\lambda}{2a}\right)^2\cos^2\psi\right)\left\{\left[\frac{4\pi a b R_o}{\lambda^2} - \frac{\eta\sin^2\psi\cos\left(\frac{\pi\lambda}{4a}\cos\psi\right)}{1-\left(\frac{\lambda}{2a}\right)^2\cos^2\psi}\right]^2 + \left(\frac{4\pi a b x_o}{\lambda^2}\right)^2\right\}^{1/2}}{\eta\cos\psi\sin\psi\cos\left(\frac{\pi\lambda}{4a}\cos\psi\right)} \qquad (6)$$

$$\phi = \tan^{-1}\frac{\dfrac{4\pi a b x_o}{\lambda^2}}{\dfrac{4\pi a b R_o}{\lambda^2} - \dfrac{\eta\sin^2\psi\cos\left(\frac{\pi\lambda}{4a}\cos\psi\right)}{1-\left(\frac{\lambda}{2a}\right)^2\cos^2\psi}}$$

The conditions for circular polarization are:

$$\left|\frac{Ey}{Ex}\right| = 1$$

$$\phi = \pm\frac{\pi}{2}$$

Substituting these conditions into equations 6 we obtain:

$$\frac{4\pi a b R_o}{\lambda^2} = \frac{\eta\sin^2\psi\cos\left(\frac{\pi\lambda}{4a}\cos\psi\right)}{1-\left(\frac{\lambda}{2a}\right)^2\cos^2\psi} \qquad (7)$$

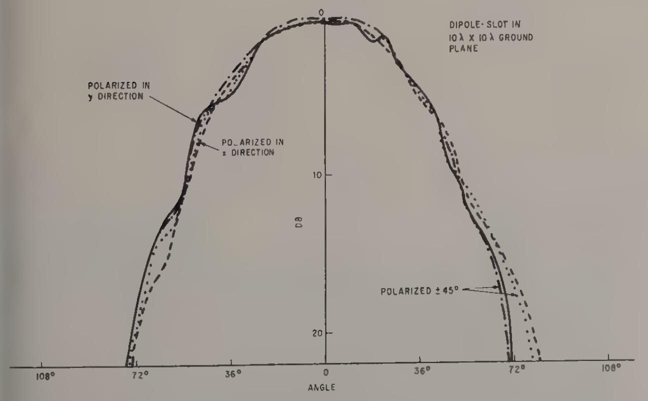


Figure 5(a) — Patterns in plane parallel to long dimension of slot for antenna of Figure 2(b). (YZ plane of Figure 1.)

and

$$\frac{\left(1-\left(\frac{\lambda}{2a}\right)^2\cos^2\psi\right)\dfrac{4\pi a b x_o}{\lambda^2}}{\eta\cos\psi\sin\psi\cos\left(\frac{\pi\lambda}{4a}\cos\psi\right)} = 1 \qquad (8)$$

By adjusting ψ, the tilt angle of the dipole, equation 7 can be satisfied, and by adjusting x_o, the reactance of the dipole plus termination, equation 8 can be satisfied simultaneously.

The value of R_o, the resistance of the dipole in the presence of the slot, is also a function of ψ as may be seen from the measured value of R_o shown in Figure 6. Using these curves for R_o the magnitude and phase angle of $\frac{Ey}{Ex}$ as given in equation 6 is plotted in Figures 3 and 4 as a function of tilt angle ψ for that frequency for which the dipole is $\lambda/2$.

Experimental Results

Either the slot or the dipole may be used as the parasitic

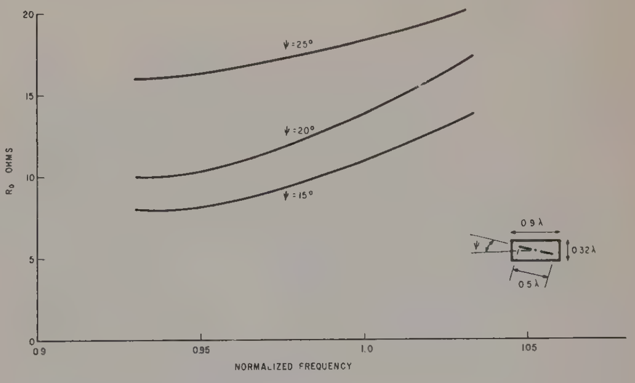


Figure 6 — Measured terminal resistance of dipole located in slot aperture.

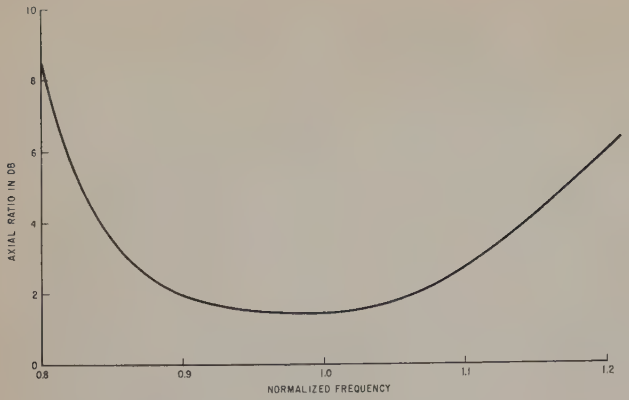


Figure 7 — Measured axial ratio vs. frequency for dipole-slot antenna of Figure 2(b).

element in the slot-dipole antenna. If the slot is excited, as was assumed in the mathematical model, a reactance must be connected across the terminals of the dipole. A possible physical configuration is shown in Figure 2(a) in which a waveguide is terminated in a ground plane, and a stub reactance is connected at right angles to an etched circuit board containing the dipole configuration.

For UHF or low frequency microwave applications it is simpler to excite the dipole with the slot acting as the parasitic element (see Figure 2(b)). In this case the slot is backed up by a cavity which shunts a reactance across the aperture to correspond to the stub in Figure 2(a). Both versions have been built and found to have circular polarization. The following experimental data applies to the antenna of Figure 2(b).

The principal plane patterns of the dipole excited slot are shown in Figures 5(a) and 5(b) with the slot mounted in a 10 x 10 wavelength flat ground plane. Axial ratios are of the order of 1 or 2 db over ±45° of the pattern maximum at the center frequency. Axial ratios over a band of frequencies were found to be best for $\psi = 18°$. It can be seen in Figure 7 that the axial ratio

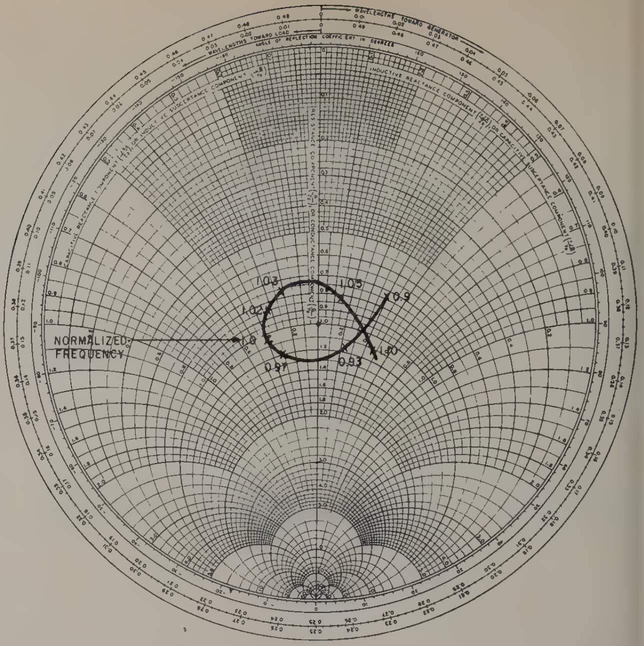


Figure 8 — Input impedance of antenna of Figure 2(b) with folded dipole feed.

Reference: Input connector, 50 ohm feed line.

on axis is less than 3 db over a 25 per cent bandwidth*. The low resistance seen at the dipole terminals requires that the dipole be folded in order to bring the resistance up to 50 ohms. This does not disturb the axial ratio in any way, since when the dipole is the excited element it is the aperture impedance of the slot in the presence of the dipole that becomes the important quantity rather than the dipole impedance in the presence of the slot which appears in equation 6. The final impedance plot normalized to a 50 ohm line for the folded dipole feed inserted in the slot of Figure 2(b) is shown in Figure 8. Maximum VSWR is approximately 1.8 over a 20 per cent band.

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* *Axial ratios were measured by continuously rotating a linearly polarized pickup antenna through 360° and recording the maximum and minimum response.*

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* * *

A TEFLON MICROWAVE WINDOW

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Introduction

It is frequently necessary to close or seal a microwave system to retain air pressure within it and to preclude the entry of water, water vapor, dust or other extraneous matter. This seal, or pressure-resistant window, is generally mounted across a section of waveguide. It must, therefore, be essentially transparent to microwave energy over given frequency and temperature ranges.

Commercial microwave pressure-resistant windows are generally constructed of electrical-grade glass fused to a Kovar metal frame[1, 2], or of mica sealed to a metal frame with a low-melting glass or a solder[3]. These metal frames are coated with some appropriate metal and then soldered to the waveguide. Apart from their cost, normally several dollars, these windows present the difficult problem of soldering or attachment by other means to aluminum waveguides and also offer some risk of corrosion due to the proximity of dissimilar metals. An experimental window, developed at these laboratories at an earlier date, employed a sheet of Teflon (DuPont polytetrafluoroethylene, 0.015 inch in thickness, clamped between two metal plates. This type of window relies on the plastic film to serve as a gasket as well as a dielectric. However, the plastic is subject to cold flow and, in time, ceases to maintain a satisfactory seal against the metal surfaces.

The development of a method for the bonding of Teflon[4] led to the use of this excellent dielectric in a new, inexpensive microwave pressure-resistant window.

Experimental Methods

1. Preparation of Surfaces

(a) *Teflon film,* 0.005 inch in thickness and devoid of pinholes, was immersed for 15 minutes in a bath containing a one molar complex of sodium-napthalene in tetrahydrofuran[4] in order to render it bondable. The film was removed from the bath, rinsed first with acetone and then with water, and then gently blotted dry with a soft tissue. The film was then ready to be cut to window dimensions and bonded.

(b) *Aluminum surfaces* to be bonded were subected to the following cleaning cycle:

I. Degreasing with acetone or methyl ethyl ketone.
II. Etching in a concentrated solution of sodium hydroxide for 3 to 4 minutes.
III. Pickling in concentrated nitric acid for 2 minutes.
IV. Rinsing with cold water and wiping dry with a clean tissue.

(c) *Magnesium surfaces* to be bonded were subjected to the following cleaning cycle:

I. Degreasing with acetone or methyl ethyl ketone.
II. Pickling for 15 to 20 seconds in a solution containing, by volume, 8 parts concentrated nitric acid, 2 parts concentrated sulfuric acid, and 90 parts water.
III. Rinsing with cold water and wiping dry with a clean tissue.

2. Fabrication of microwave flanges

Two types of test flanges were fabricated:

Type A—This type of test flange consisted of a flat "half-guide" flange, with two positioning dowel pins in its surface and an outer alignment-frame, 0.050 inch in thickness, with two holes to match the pins in the flange (See Figure 1). The outside dimensions of this frame were those of the flange itself and the inside dimensions were 0.400 inch in width by 1.100 inches in length. An insert in the shape of a rectangular frame 0.045 inch in thickness was also provided to fit within the alignment frame. This insert constricted the opening above the window to the original "half-guide" dimension, i.e., 0.900 inch by 0.200 inch and provided additional stiffness to the Teflon film. All the metal parts were fabricated of aluminum. All sharp metal edges expected to make contact with the Teflon film were de-burred.

Type B—This fixture was a simplified simulation of a microwave flange and consisted of a solid aluminum or magnesium cylinder, 1.5 inches in diameter and 0.75 inch long, machined so as to assure the shape of a short section of waveguide mounted on a disc (see Figure 2). The back end of the disc-shaped base was drilled and tapped to accommodate a standard 0.5 inch threaded pipe. The tapped hole joined the rectangular opening of the short waveguide section so that air could freely pass from one to the other. A flat aluminum or magnesium rim,

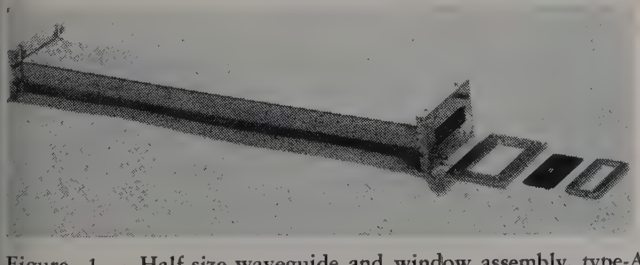


Figure 1 — Half-size waveguide and window assembly, type-A flange with alignment frame, Teflon window, and insert.

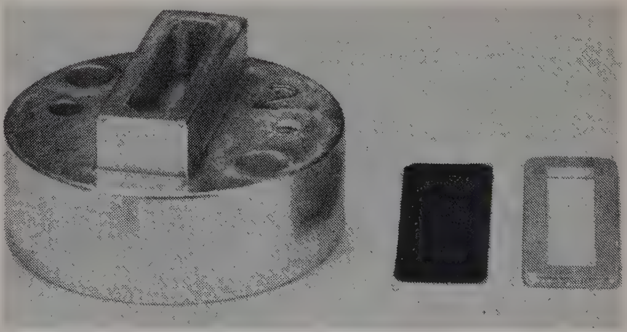
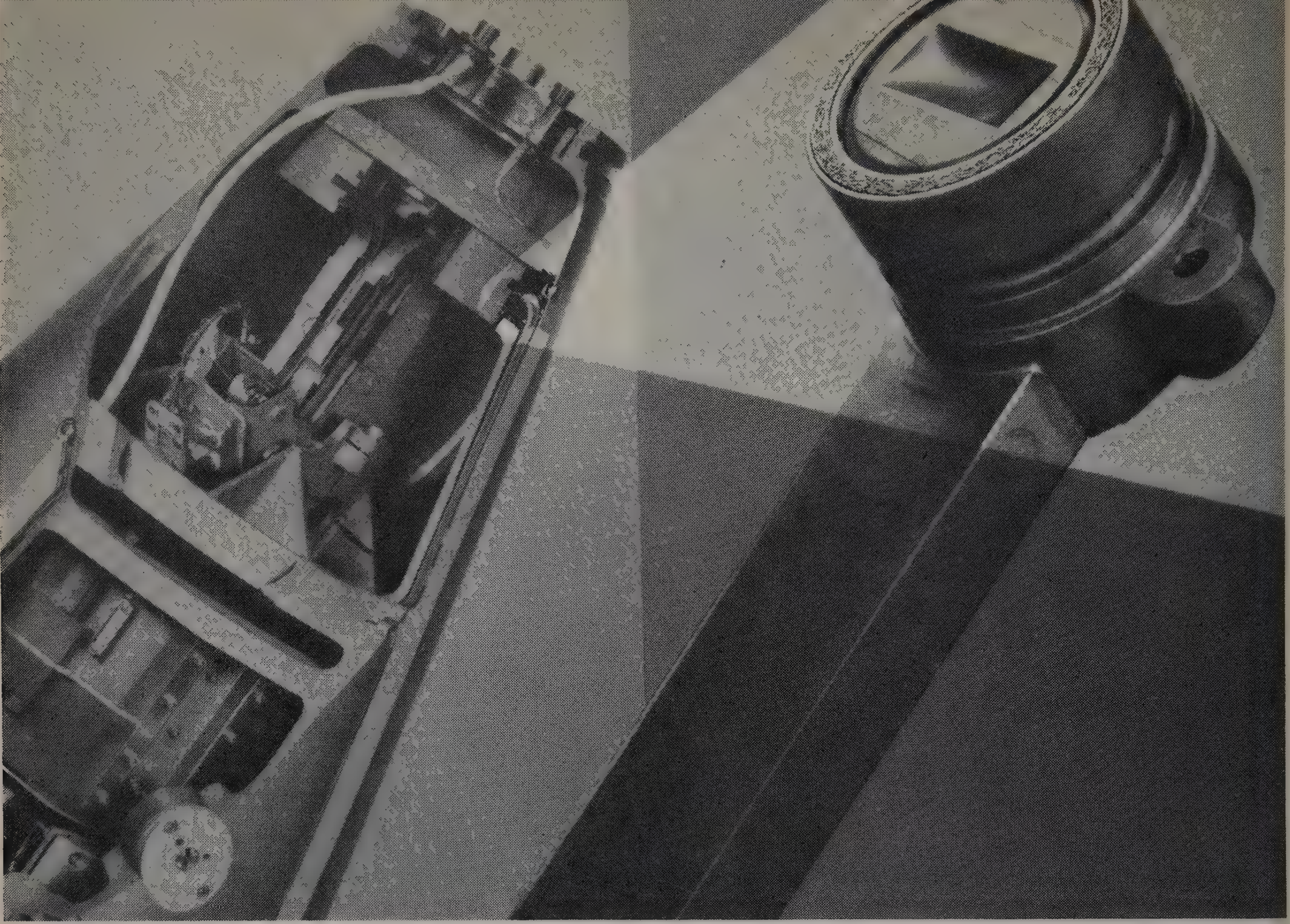


Figure 2 — Simulated microwave flange, type-B, with Teflon window and metal stiffening rim.



An enlargement of a Teflon microwave window and a part of a missile electronic system in which several windows of its kind are used. This inexpensive window, capable of maintaining a pressure differential of more than an atmosphere at elevated temperatures, was developed by the Army's Diamond Ordnance Fuze Laboratories, Washington, D.C.

like the insert in the Type-A flange, provided a similar stiffening function to the Teflon film. Here also, all sharp contact edges were de-burred.

3. Formulation of adhesive

The adhesive was compounded from the following ingredients:

Constituent	*Parts by weight*
Epoxy resin (viscosity 5-9 poises)	25
Chlorendic anhydride	25
Acetone	30
Methyl ethyl ketone	20

The chlorendic anhydride was first dissolved in the mixture of solvents. The epoxy resin was then added, and the final mixture was shaken to obtain complete solution. This adhesive had a water-like consistency at room temperature and its shelf life exceeded three months.

4. Bonding of window in test assembly.

(a) Application of adhesive.

A very thin layer of adhesive, less than 0.0005 inch in thickness, was painted over one entire side of the Teflon window and on the contact surfaces of the flange and insert.

All surfaces coated with adhesive were dried at room temperature for 15 minutes and then at 65°C (149°F) in a forced-draft oven for one hour. The parts were then dry to the touch and could, if desired, be stored for several days prior to assembly and final cure.

(b) Where type-A flanges were used, the window parts were assembled (See Figure 3, upper section) and fitted into a yoke (Figure 4) containing a calibrated spring. A pressure of 20±5 psi was applied to the bond surfaces through a pad of silicone rubber and maintained through the period of curing.

Where type-B flanges were used, the windows were assembled as in Figure 3, lower section ,stacked in a tube face-to-face (See Figure 5) and here, too, a spring-pressure of 20±5 psi was maintained during cure.

(c) Curing the adhesive.

Curing of the adhesive under the pressure described above was effected at a temperature of 200°C in a forced-draft oven for one hour.

5. Evaluation of window assemblies.

The evaluation of Teflon windows consisted of (a) determining the adequacy of the bond in terms of its resistance to air pressure at elevated temperatures, (b) subjection of bonded assemblies to temperature and humidity cycling followed by bond testing, and (c) measuring the microwave reflections due to the presence of the window in a microwave line.

(a) Bond test.

The section of waveguide (type-A flange) containing the window was connected to a pressurizable unit consisting of another section of waveguide, an air valve, and a pressure gage (See Figure 6). The type-B flange was connected directly to the gage and air valve by a short length of pipe. Compressed air was admitted through the valve until a pre-determined pressure was attained. The

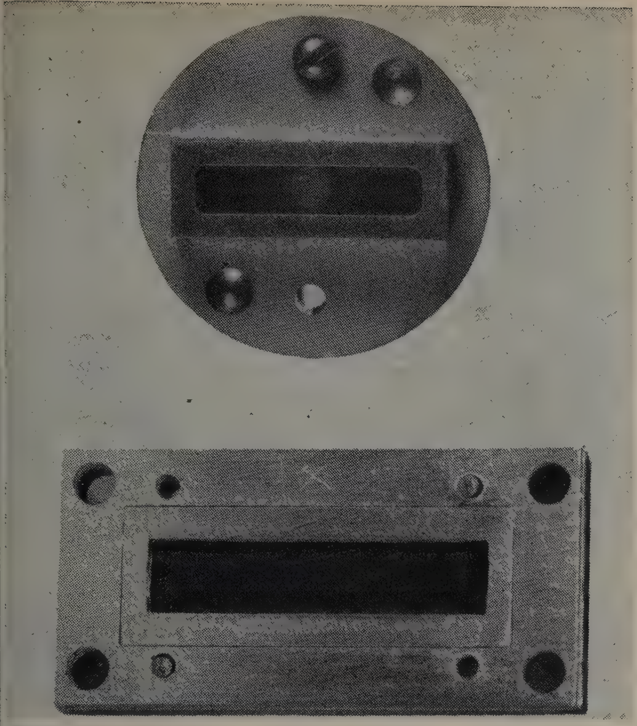


Figure 3 — Top: Assembled type-A window. Bottom: Assembled type-B window.

end of the assembly that contained the window was inserted into a tube-furnace (See Figure 7) maintained at the requisite temperature by the regulation of a variable auto-transformer. The precise temperature at the window was indicated by a thermocouple attached to the flange.

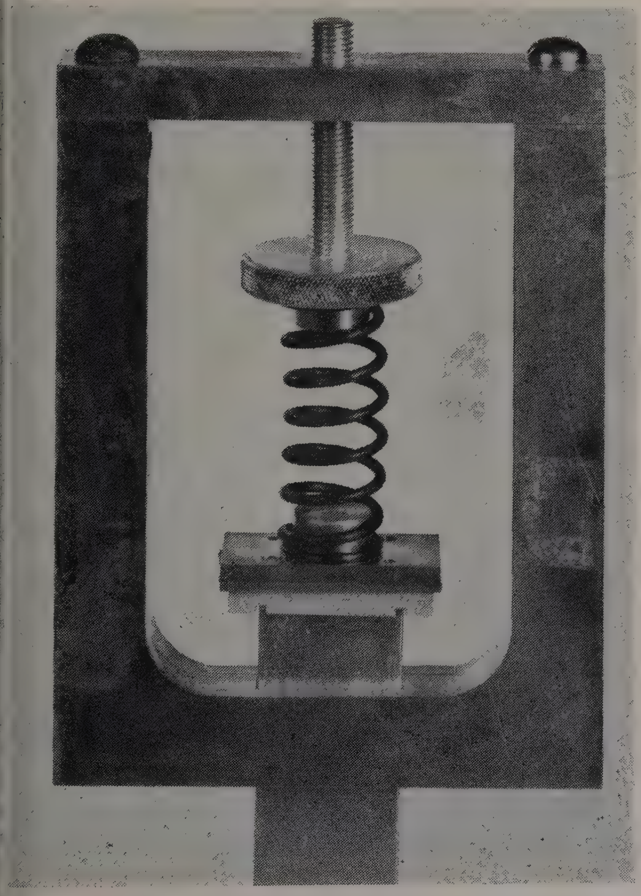


Figure 4 — Jig for assembling of type-A waveguide window.

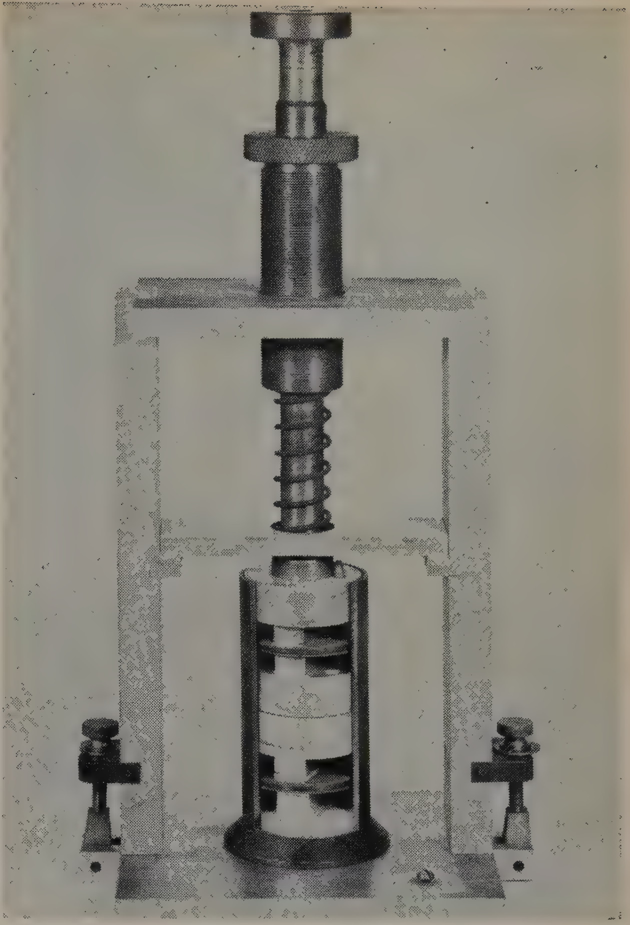


Figure 5 — Jig for assembling of 4 type-B simulated waveguide windows.

The test was considered to start at the time the flange reached the required temperature and continued for 15 minutes. The temperature of the flange and the gage pressure were noted throughout the test. A decrease in pressure indicated the presence of substantial leaks and denoted failure of the window assembly. Windows that passed muster at the test temperature were then re-tested at the next level of temperature. Results are given in Tables I, II, and III.

(b) Environmental test.

Four type-A flanges with bonded Teflon windows that tested successfully at 125°C (as in the above bond test procedures) were subjected to environmental cycling as follows:

> 24 *temperature cycles* each consisting of one hour at − 80°F, one hour rise to + 185°F, one hour at + 185, and three hour drop to − 80°F.
>
> 15 *humidity cycles* each consisting of two hours at 50 per cent and two hours at 100 per cent relative humidity (R.H.).

These same four assemblies were again tested in accordance with the identical bond test procedure to determine whether the bond had been undermined by the environmental exposure. These results are given in Table IV.

(c) Electrical test.

The section of waveguide containing the window was connected to a waveguide assembly that allowed for the measurement of the voltage standing wave ratio (VSWR) by slotted line techniques. Such measurements were made at a particular microwave frequency, f_o, and at frequencies

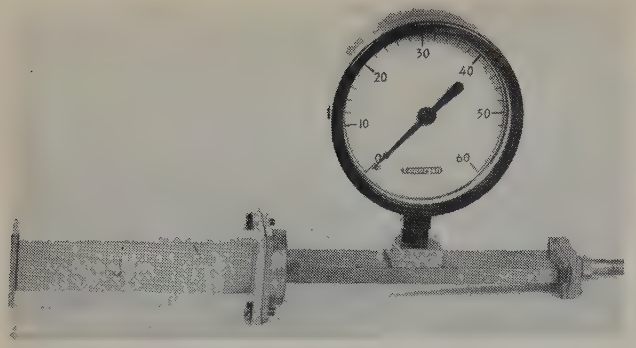


Figure 6 — Apparatus for applying air pressure to window bonded in left end of waveguide.

200 megacycles above and below f_o. The VSWR values resulting from the insertion of each of 10 windows into the waveguide assembly are given in Table V.

Discussion

It may be seen in Table I that 0.005 inch thick Teflon windows bonded in a typical aluminum "half-size" waveguide flange can successfully confine an air pressure in excess of 25 psig at a temperature of 150°C for 15 minutes. When the test temperature was raised to 175°C about half of these windows failed. On the other hand, as shown in Table II, similar windows bonded to aluminum, plug-type, simulated flanges reproducibly withstood the same pressure at a temperature of 200°C. This distinction in temperature resistance bears an apparent relationship to flange design; this indicates that some third configuration may vary in bond behavior from the two herein described configurations.

It is clear from a comparison of Tables II and III that magnesium-housed windows are substantially inferior in temperature resistance to aluminum-housed windows of identical design. This was not unexpected since most epoxy adhesive bonds to magnesium are weaker than corresponding bonds to aluminum[5].

The test recorded in Table IV indicates that Teflon windows bonded into aluminum flanges can undergo temperature and humidity cycling and subsequently withstand the usual pressurization at 125°C.

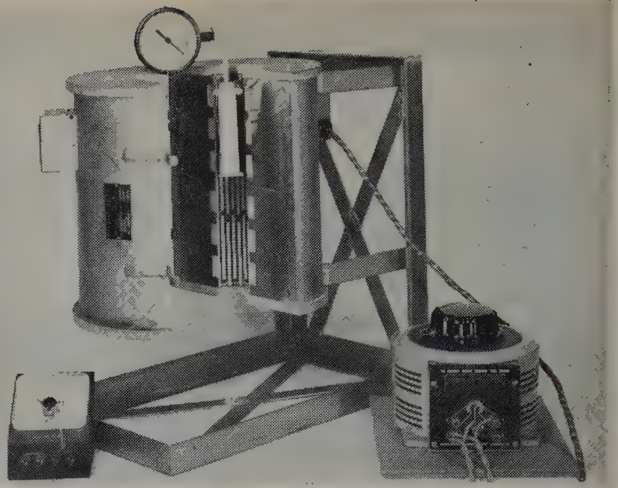


Figure 7 — Tube furnace for testing the resistance of bonded windows to air pressure at elevated temperatures.

From Table V it is apparent that the insertion of the 0.005 inch thick Teflon window into the line of a microwave assembly did not increase the voltage standing wave ratio (VSWR) beyond 1.08 when measured within a band consisting of 200 megacycles on either side of a particular microwave frequency. Spot tests further indicated that the VSWR may vary insignificantly between frequencies of 8000 and 10,000 megacycles. This maximum value of 1.08 can be compared with values in excess of 1.1 which are typical of commercial glass or mica windows.

Sealed glass or mica windows generally cost several dollars; this type of cemented Teflon window can probably be produced for a small fraction of this cost. Figure 8 shows portions of the microwave antennas of two guided missiles. In both cases the feed end of the antenna is sealed off by a bonded Teflon window.

Qualitative tests indicated that 0.005 inch thick Teflon film may not have sufficient intrinsic strength to withstand pressures much in excess of 25 psig, particularly if the window is intended for a full-size waveguide having internal dimensions of 0.400 inch by 0.900 inch. In such cases, 0.010 inch thick film has proved usable but has raised the VSWR to values slightly in excess of 1.1.

TABLE I: Resistance to air pressure of microwave windows on aluminum type-A flanges, tested at elevated temperatures.

Window No.	15 Minute Test Rating at 150°C (27 psig)	175°C (28 psig)	200°C (29 psig)
1	passed	failed	- - - -
2	passed	passed	failed
3	passed	failed	- - - -
4	passed	failed	- - - -
5	passed	passed	failed
6	passed	failed	- - - -
7	passed	passed	passed
8	failed (1)	- - - -	- - - -
9	failed (2)	- - - -	- - - -
10	passed	passed	passed
11	passed	passed	failed

(1) No. 8 failed after 5 minutes
(2) No. 9 failed after 3 minutes

TABLE II: Resistance to air pressure of microwave windows on aluminum, type-B flanges, tested at elevated temperatures.

Window No.	15 Minute Test Rating at 200°C(27 psig)	225°C(27 psig)	250°C(28 psig)
1	passed	failed	- - - -
2	passed	failed	- - - -
3	passed	passed	passed
4	passed	passed	passed
5	passed	passed	passed
6	passed	passed	passed
7	- - - -(1)	- - - -	- - - -
8	- - - -(1)	- - - -	- - - -
9	- - - -(1)	- - - -	- - - -
10	- - - -(1)	- - - -	- - - -
11	passed(2)	- - - -	- - - -
12	passed	failed	- - - -
13	passed	passed(3)	- - - -
14	passed	passed	passed
15	passed	failed	- - - -
16	passed	passed	passed

(1) Leaked at room temperature; no further test.
(2) small leak at 200°C; no further test.
(3) faulty temperature control; no further test.

The epoxy-solvent adhesive system employed in this work contains solvents which reduce its viscosity to a water-like consistency at room temperature. Although the use of solvents in epoxy systems is not new, the particular formulation combines several characteristics not normally available in a single adhesive.

1. The adhesive is of sufficiently low viscosity to allow extremely thin layers, less than 0.0005 inch in thickness, to be painted on the microwave windows. Because of the thinness of the adhesive layer, it has no significant effect on the electrical behavior of the window. Therefore, when the entire window is painted with adhesive, it is not necessary to mask the transmission area of the window.

TABLE III: Resistance to air pressure of microwave windows on magnesium, type-B flanges, tested at elevated temperatures.

Window No.	15 Minute Test Rating at 125°C(24 psig)	150°C(26 psig)	175°C(27 psig)
1	passed	passed	failed
2	passed	failed	- - - -
3	passed	failed	- - - -
4	passed	failed	- - - -
5	- - - -(1)	- - - -	- - - -
6	- - - -(2)	- - - -	- - - -
7	passed	failed	- - - -
8	passed	failed	- - - -
9	passed	failed	- - - -
10	passed	failed	- - - -
11	passed	failed	- - - -
12	- - - -(3)	failed	- - - -
13	- - - -(3)	failed	- - - -
14	- - - -(3)	passed	failed
15	- - - -(3)	passed	failed
16	- - - -(3)	failed	- - - -

(1) leaked at room temperature; no further test.
(2) faulty temperature control; no further test.
(3) no test performed at this temperature.

TABLE IV: Resistance to air pressure of microwave windows on aluminum, type-A flanges, tested at elevated temperatures before and after temperature and humidity cycling.

Window No.	15 Minute Test Rating at 125°C(25 psig)	
	before cycling	after cycling
1	passed	passed
2	passed	passed
3	passed	passed
4	passed	passed

TABLE V: VSWR at various frequencies(1) for a microwave line containing polytetrafluoroethylene microwave windows.

Assembly No.	Voltage standing wave ratios Frequencies		
	$f_o - 200$	f_o	$f_o + 200$
1	1.04	1.06	1.06
2	1.04	1.05	1.03
3	1.04	1.04	1.06
4	1.06	1.05	1.02
5	1.05	1.02	1.04
6	1.02	1.04	1.05
7	1.02	1.04	1.05
8	1.03	1.08	1.08
9	1.03	1.08	1.08
10	1.04	1.03	1.05

(1) *Actual value of f_o is not given because of security considerations.*

2. The adhesive layer is dried prior to bonding, resulting in ease of assembly.
3. A pressure of 20 psig is adequate to cause one dry film of adhesive to bond to another at the curing temperature.
4. The adhesive has capability at high temperatures.
5. Shelf life of the adhesive at room temperature was found to exceed three months.

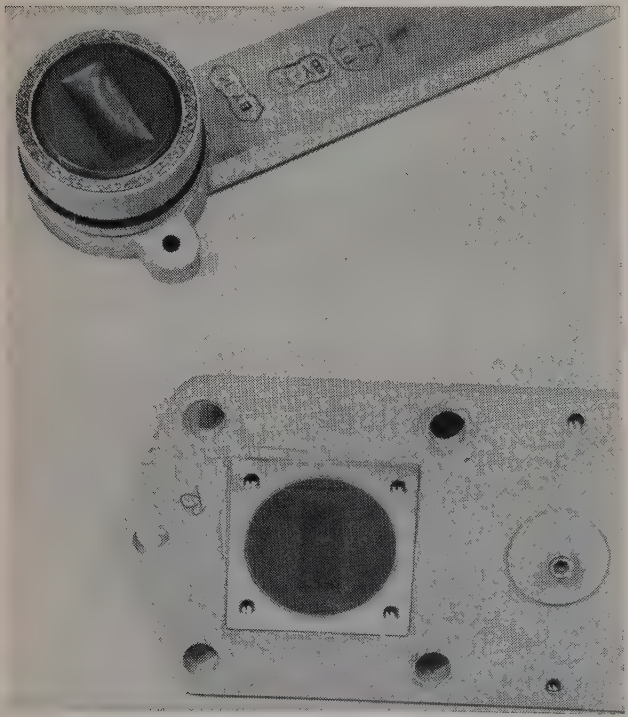


Figure 8 — Teflon windows across feed end of microwave antennas on two guided missiles.

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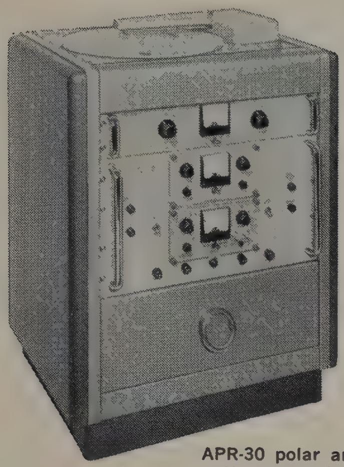
3. Sylvania Electric Products Final Engineering Report #24, "Development of Broadband Windows for Microwave Components," July 1, 1950. (Contract W-28-099 AC300).
4. Nelson, E. R., Kilduff, T. J., and Benderly, A. A., Ind. Eng. Chem. 50, 329 (1958)
5. Bodnar, M. J., Schrader, W. H., and Wegman, R. F., Feltman Research and Engineering Laboratories (Picatinny Arsenal) Technical Report 2598, April 1959.

Acknowledgment

The authors wish to acknowledge the constant cooperation and encouragement extended to them during the course of the work by K. E. Woodward, R. R. Palmisano, H. S. Jones, and W. G. Heinard of these laboratories.

Flexibility and Refinement

APR-20 rectangular antenna pattern recorder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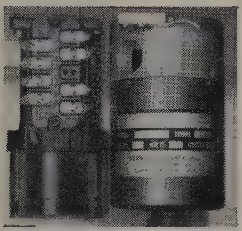
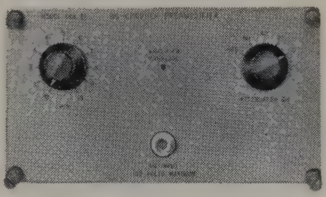

Series P plug-in pen balancing potentiometers

Series P potentiometers are used in both rectangular and polar coordinate pattern recorders. By interchanging potentiometers together with the appropriate pen function amplifier, different responses—linear, square-root, and logarithmic—are obtained. Interchanging these new self-aligning potentiometers can be accomplished in less than thirty seconds. Stocking spare units cuts downtime. Of dust and dirt proof construction, Series P plug-in balancing potentiometers are offered with exchange pricing.

DC Amplifiers...


DCA-21 amplifier for dc input signals

Scientific-Atlanta's DCA-21 amplifier lets APR 20/30 recorders accept dc input signals. A narrow band amplifier preceded by an electromagnetic chopper, the sensitive DCA-21 has a linear dynamic range of 80 db. The unit is directly interchangeable with Series CBA-20 Crystal-Bolometer amplifiers.

Recorder Pen Programmers...

Up to five different pen writing codes can be selected by adding the Model RPP-1 Recorder Pen Programmer to an APR 20/30 installation. Compact, lightweight, and rack mounted, the programmer provides solid line, dot, dash, dash-dot, and space-dot-dot codes at an adjustable code rate of 30 to 90 cycles per minute.

Modification C, Chart Compression...

Modification C, which must be ordered at the time of recorder purchase, provides both standard and compressed cycle charts from a single APR 20 Rectangular pattern recorder. Standard chart cycle is 20 inches, compressed 8 inches. Compressed recordings are conveniently sized to fit standard 8½ x 11 notebooks and reports.

Chart Paper, Recording Pens, Ink, and Accessories...

Scientific-Atlanta offers its customers one-day service by stocking, for immediate delivery, a wide variety of chart paper, recording pens, and other recording necessities.

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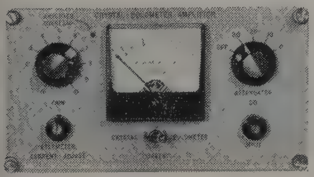
High gain, low noise crystal-bolometer antenna

Sensitive, narrow-band Crystal-Bolometer amplifiers are miniaturized units designed for use as preamplifiers in S-A polar and rectangular pattern recorders. Five models, CBA-21 through CBA-25 are available. Features include bolometer burnout protection, low noise figure, triaxial signal ground return, up to 108 db gain, 80 db linear dynamic range, adjustable bandwidth (CBA-23), high rejection (CBA-24), variable center frequency (CBA-25).

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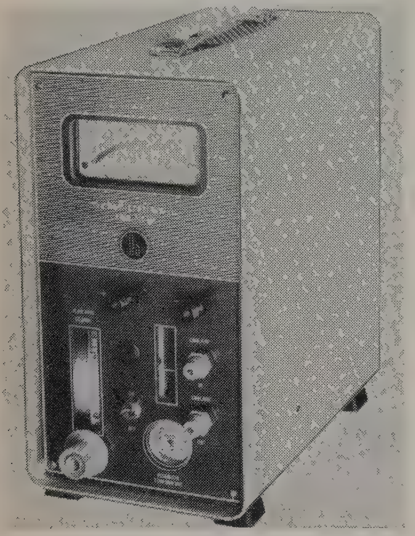
7

New Products

PORTABLE R-F CALORIMETER OFFERED BY HALLICRAFTERS



The Hallicrafters Company, Chicago, Ill., announces a self-contained Model RFC-15B portable R-F Calorimeter for field or laboratory use. The unit performs radio-frequency measurements to 1500 watts average power (15 kilowatts peak) with an accuracy of ±5 per cent.

The Calorimeter consists of liquid circulator and calorimetric termination (r-f load). Terminations are available from dc to 5000 Mc.

Circulator contains pump, fan, 115 vac motor, control valves, heat exchanger, flow meter, liquid reservoir and direct-reading power meter. Weight is 42 pounds.

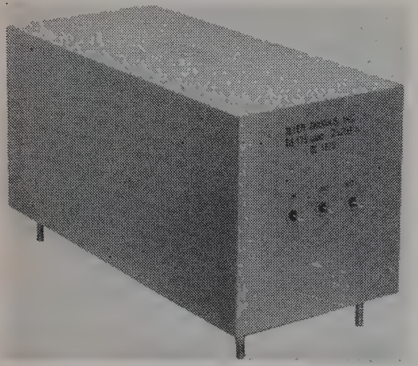
Circle Reader Service Card 110

—*mwj*—

LUMPED CONSTANT DELAY LINES AVAILABLE FROM ALLEN AVIONICS

A new series of lumped constant delay lines has been introduced by Allen Avionics, Inc., Mineola, N. Y.

These new lines which achieve delay/rise time ratios as high as 175:1 were designed for use in radar sets for shipboard or ground support equipment installations. Known as the DL-1000 Series, these lines are available in delays to 500 microseconds with impedances ranging from 100 - 1000 ohms, and have been designed to operate in ambient temperatures from −55°C to +125°C.



The DL-1175 has a total delay of 175 microseconds and a rise time of 1.0 microseconds, giving it a delay/rise time ratio of 175:1. Its impedance is 200 ohms, attenuation 6 db maximum, and distortion is seconds, giving it a delay/rise time ratio held to 3½ per cent maximum. Dimensions of the DL-1175 (11½ inches long x 5½ inches wide x 5½ inches high) were held to conform with existing specifications, however, greater packaging density can be obtained to meet customer requirements. Provisions for mounting can also be revised to customer's needs.

Delivery is two weeks on the DL-1175 and three to four weeks on prototypes of other units.

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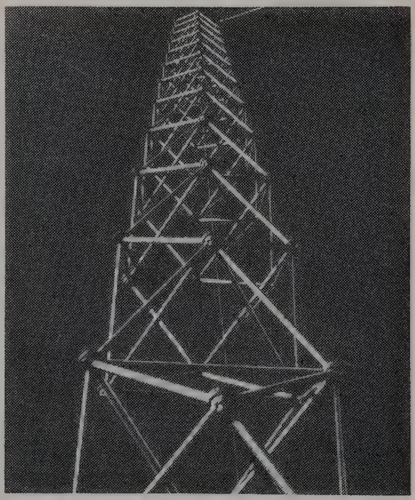
—*mwj*—

OCTAHEDRON TOWER FEATURES 1/3 GREATER LOAD CAPABILITY



Development of the octahedron tower with one-third greater load capability and six times greater torsional rigidity than conventional towers has been announced by Up-Right Towers, Berkeley, Cal.

Lightweight and portable, the tower is an assembly of octahedral or eight-sided sections. The tower is quickly erected using just two basic parts: identical struts and ball-shaped joints. Struts are available in aluminum alloy, steel or fiberglass of appropriate lengths, diameters and wall thicknesses for specific tower requirements. Components occupy an absolute minimum space for storage or transportation.

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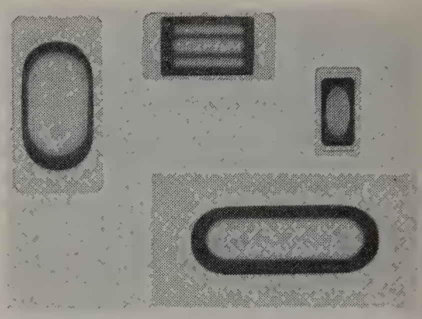
—*mwj*—

SOLDERABLE PRESSURE WINDOWS OFFERED BY MICROWAVE DEVELOPMENT



A full line of solderable waveguide pressure windows is now available from Microwave Development Laboratories, Inc., Wellesley, Mass. These pressure windows provide an air-tight seal within waveguide systems, yet are transparent to microwave energy. They maintain pressure to assure maximum performance and prevent entry of moisture, dirt or dust.

MDL solderable waveguide pressure windows are designed for use with EIA waveguide sizes WR-90, WR-112, WR-187 and WR-284. All windows are silver plated to reduce rf loss.

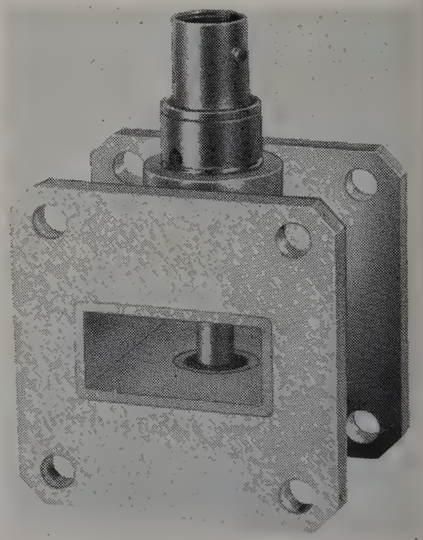
Circle Reader Service Card 113

—*mwj*—

BROADBAND SWITCHES NOW PRODUCED BY AEL

AEL, Inc., Philadelphia, Pa., has announced the addition of broadband solid state waveguide switches to its line.

The Model SWB115A with a range of 8.2 — 10 kMc is an addition to a line, already in production, covering various ranges from 8 kMc — 16 kMc. Other ranges are now being developed.



(*Continued on page 110*)

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BASIC DATA	**526**	**527**	**528**
Frequency Range	12.4 to 18 Kmc	8 to 12.4 Kmc	7 to 11 Kmc
Power Output	1 watt	2 watts	5 watts
Gain (Small Signal)	30 db	30 db	30 db
Gain (Saturation)	25 db	30 db	30 db
VSWR (Input/Output)	2:1	2.5:1	2.5:1
RF Connectors	P Band Flange VG-419/U	Type N Female	Type N Female
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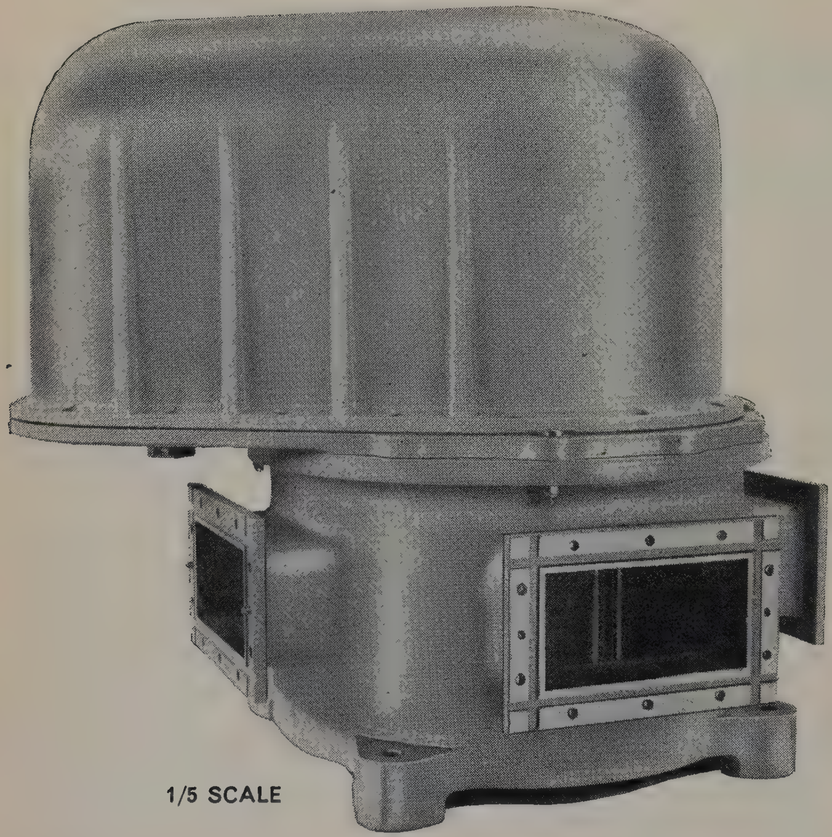

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Circle Reader Service Card 62

New Products

(Continued from page 108)

Insertion losses of less than 1.5 db and isolations of 15 db are typical of this new line of switches. For special orders with restricted frequency ranges, isolations as high as, or higher than, 36 db can be provided. Insertion losses can be held to a few tenths of a db.

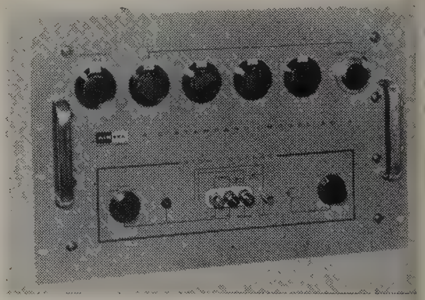
The SWB115A will handle up to 1 watt of RF power with only 30 mw of switching power required. It is available in SPST and SPDT configurations and is designed for UG (39)/U input and output. Ease of crystal replacement in the field is another desirable feature of this switch.

These crystal units may be used as switches, as variable attenuators, modulators, and in the SPDT models may be used for antenna and channel switching.

Circle Reader Service Card 114

—*mwj*—

KIN TEL DIVISION OFFERS AC VOLTAGE STANDARD



Rapid, direct-calibration of high-accuracy ac measuring instruments is a major application of the new Model 601A ac voltage standard manufactured by Kin Tel Division of Cohu Electronics, Inc., San Diego, Cal.

The 601A is an extremely stable and accurate ac voltage source and its calibration capability simplifies a heretofore complicated and time-consuming task. Other uses include gyro and servo system design and testing, evaluation of magnetic properties and other general purpose applications in electronic laboratories or calibration facilities.

Key features of the Kin Tel 601A include its ability to supply from 1 - 501 volts; 60, 400, 1000 cps output frequencies; voltage accuracy to 0.1 per cent; short term voltage stability of 0.01 per cent; frequency accuracy of 1.0 per cent; less than 0.3 per cent harmonic distortion, and power output 5 amps - 5 volts, 25 watts above 5 volts.

Price is $4500 FOB, San Diego, Cal., and delivery is one week.

Circle Reader Service Card 115

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(Continued on page 112)

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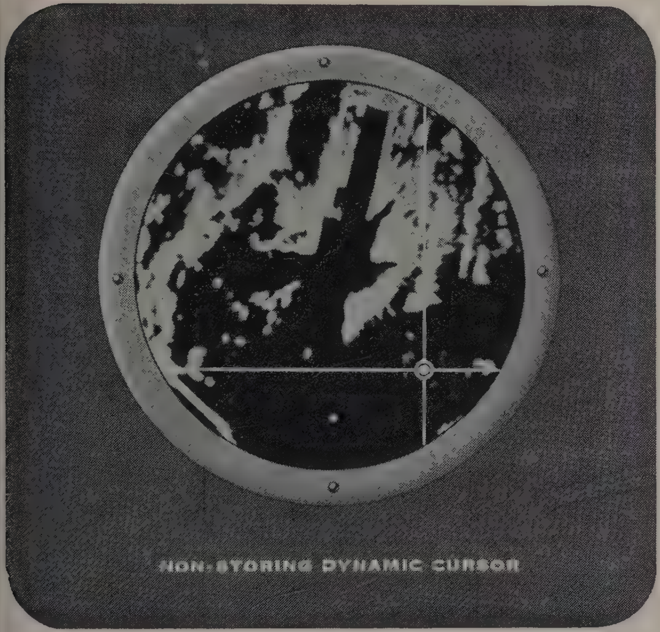

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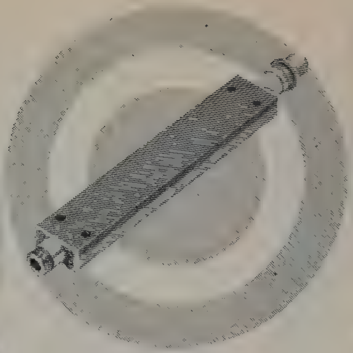

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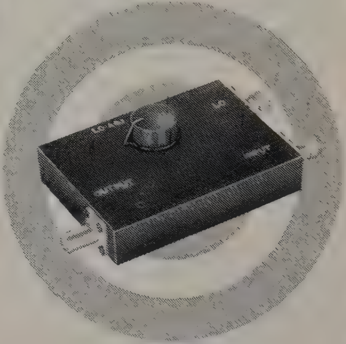

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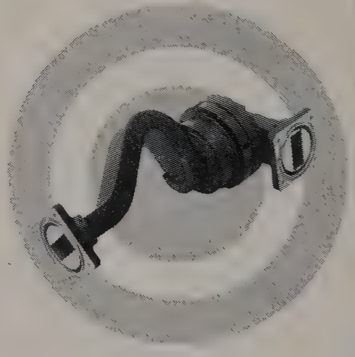

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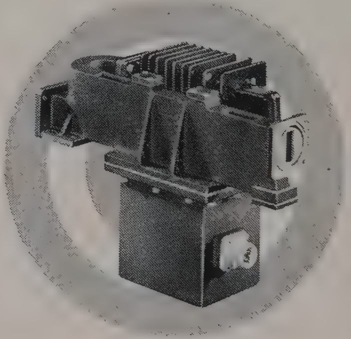

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Specialists in the design and manufacture of microwave components in the missile and guidance fields, Premier offers unsurpassed engineering knowledge and experience plus modern manufacturing facilities and the most advanced and accurate testing equipment to keep your job on target.

ENGINEERS can depend upon Premier to meet the most exacting specifications and, through precise quality control, deliver complete uniformity and operating performance.

BUYERS concerned with both initial and long range costs find at Premier facilities geared to produce competitively as well as design engineering which can often effect further economies through more accurate interpretation of performance requirements and improved working efficiency.

Premier's Engineering Division is qualified to tackle any problem, whether it involves a standard waveguide unit or an intricate new design. Our complete model shop is also available to aid in your developmental work. Bring your problem to Premier . . . Premier will bring the answer to you.

PMC

PREMIER MICROWAVE CORPORATION
33 New Broad Street, Port Chester, N. Y.
Building for Today's Equipment—Researching for Tomorrow's Demand

---

New Products

(*Continued from page 110*)

ELECTRICALLY TUNABLE KLYSTRON ANNOUNCED BY METCOM

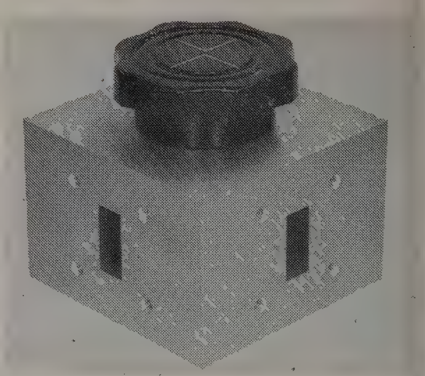
Metcom, Inc., Salem, Mass., announces the design and production of the MXK-23 klystron, an electrically tunable reflex klystron with a tuning range greater than 400 Mc. It is for use in the X-band region, in radar equipment and test equipment, as local oscillator or as wide band sweep oscillator.

The MXK-23 differs from standard tunable klystrons in that it is tuned in the conventional mechanical manner and is electrically tuned for 400 Mc from any mechanical setting. The electrical tuning feature affords the advantage of simplified circuitry, while the easy, rapid tuning makes it ideal for AFC circuitry.

Circle Reader Service Card 116

—*mwj*—

WAVEGUIDE SWITCHES IN 7 SIZES OFFERED BY WAVELINE



Waveline Inc., Caldwell, N. J., has announced the availability of precision Waveguide Switches in seven waveguide sizes to cover the frequency range of 3.95 - 40.0 kMc.

These manually operated devices have been designed for applications in the laboratory or for microwave systems to make alternate connections between two waveguide inputs and two waveguide outputs.

Excellent electrical characteristics are achieved by precision machining and assembly techniques which Waveline has developed. Full waveguide range operation is obtained with a VSWR of 1.10 maximum and an isolation greater than 60 db.

The switches are normally supplied with rotation in the narrow wall plane (circular bend of the rotor in the "E" plane) and are manually operated by means of a knob. Also available are "H" plane versions which are designated by suffix letter H.

Circle Reader Service Card 117

—*mwj*—

(*Continued on page 114*)

Ready for you now!

Primary standard accuracy for power measurements to 1,000 watts!

See us at I.R.E.
Third Floor — Just Behind Escalator

Sierra 290B Test Set

Frequency coverage dc through 12.4 KMC.

Guaranteed power measuring accuracy of 1%. Probable accuracy better than 0.5%. Precise ac wattmeter, calorimeter and heat exchanger in one neat, rack unit. Separate dual loads for dc to 4 KMC, also C, XB, X bands. Direct reading linear scale.

Above are highlights of the new Sierra 290B Calorimetric Wattmeter Test Set—the industry's closest approach to absolute power measurements in this range.

Model 290B measures power in three distinct modes.

1. For power levels 30 to 1,000 watts, a null-balance mode provides measurement accuracies of 1% or better, with probable error as low as 0.5%.

2. For wider range power levels from 10 to 1,500 watts, a direct-reading mode provides excellent linearity in thermal readout and 2% to 3% accuracy. Readout is fast—60 seconds or less.

3. For expanded scale readings of highest resolution, the above two modes may be combined in a third mode to obtain the order of accuracy of the null-balance mode, together with the time-saving convenience of the direct readout mode.

Model 290B, $4,500.00. (Water loads, extra.)

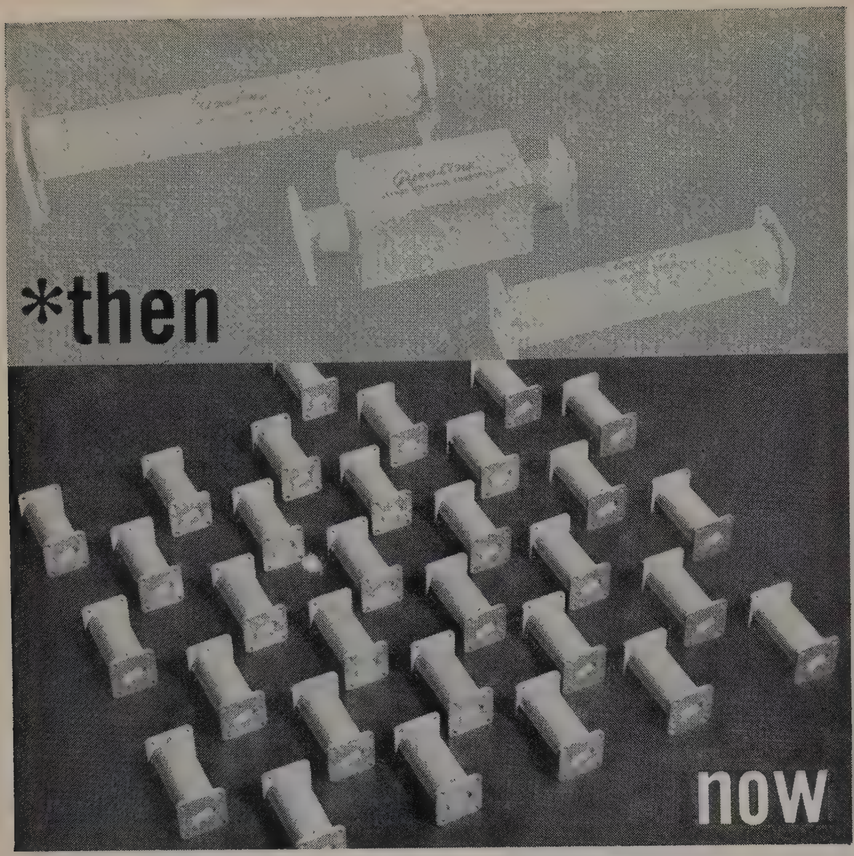
Data and prices subject to change without notice. Prices f.o.b. factory.

Laboratory setup above shows Sierra Model 215 Power Source being used in conjunction with Model 290B Calorimeter to calibrate Sierra Bi-Directional Power Monitor. Designed specifically for calibration purposes, 215 series Sources include four 50 watt models covering, collectively, 25 to 1,000 MC. Model 215A, 25 to 50 MC; Model 215B, 50 to 150 MC; Model 215C, 150 to 470 MC; Model 215D, 470 to 1,000 MC. Price (any model) $3,300.00.

For complete details, see your Sierra representative or write direct

SIERRA ELECTRONIC CORPORATION
A Division of Philco Corporation
6560C BOHANNON DRIVE • MENLO PARK, CALIFORNIA • DAvenport 6-2060
Sales representatives in all principal areas
Canada: Atlas Instrument Corporation, Ltd., Montreal, Ottawa, Toronto, Vancouver.
Export: Frazar & Hansen, Ltd., San Francisco, California.
6560

sierra



it pays to rely on experience

new low prices on microwave ferrite components

years of experience, increased production capacity, highly efficient production methods, and new technical advances permit price reductions at no sacrifice in quality. Covering the full waveguide band, these units are employed in broadband isolator and test equipment applications.

In addition to the complete line of standardized microwave ferrite components, Cascade can develop special units for your particular application.
Please write for additional information

CASCADE **UNILINE**® LOAD ISOLATORS
Waveguide and Coaxial Types (Partial List)

SPECIFICATIONS							PRICES	
FREQ. RANGE KMC	MODEL NO. (USE FOR ORDERING)	ISOL. BAND ENDS DB	MAX. ISOL. (NOM) DB	FWD. LOSS	VSWR INPUT	GUIDE SIZE	THEN	NOW
K BAND 12.4-18.0	KU-14-3	13	18	0.8	1.10	RG91/U	$248	**$195**
X BAND 8.2-12.4	X-12-25	40	50	1.0	1.15	RG52/U	297	**195**
8.2-12.4	X-12-29	30	40	1.0	1.15	RG52/U	240	**175**
7.0-10.0	XL-12-7	40	50	1.0	1.15	RG51/U	300	**225**
7.0-10.0	XL-12-10	30	40	1.0	1.15	RG51/U	270	**195**
C BAND 5.85-8.2	J-12-65	40	50	1.0	1.15	RG50/U	297	**240**
5.85-8.2	J-12-70	30	40	1.0	1.15	RG50/U	242	**225**
3.95-5.85	G-12-4	20	25	1.0	1.30	RG49/U	300	**295**
4.0-7.0	CN-12-1	10	25	1.0	1.25	⅜ COAX	225	**195**
S BAND/ L BAND 2.5-3.8	CN-12-4	10	17	1.0	1.30	⅜ COAX	225	**195**
1.7-2.3	CN-12-5	15	20	1.0	1.20	⅜ COAX	350	**290**
1.2-1.5	CN-12-17	10	10	1.0	1.20	⅜ COAX	358	**350**

ALL UNITS AVAILABLE FROM STOCK

CASCADE RESEARCH
DIVISION OF LEWIS AND KAUFMAN ELECTRONICS CORP.
5245 San Fernando Road West • Los Angeles 39, California
CHapman 5-6966 • TWX GLDL-CAL 4427
REPRESENTATIVES IN ALL PRINCIPAL CITIES

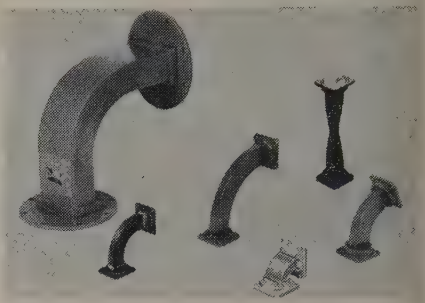
**First Microwave units produced by Cascade Research*

Circle Reader Service Card 66

New Products

(*Continued from page 112*)

WAVEGUIDE OFFERS ONE WEEK DELIVERY OF ITS PRODUCTS



Waveguide, Inc., Costa Mesa, Cal., now offers delivery of standard waveguide assemblies in less than a week.

"E" and "H" plane standard bend and twist blanks are available "on the shelf" for immediate cutting to length and brazing of any flange arrangement.

Components are supplied in either copper or aluminum with medium grey paint over standard metal finishing. Customers may specify other colors.

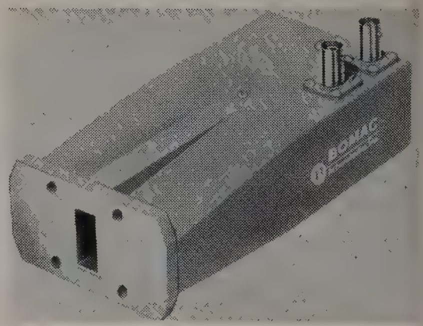
Ordering information should include "A" and "B" dimensions, angle of bend or degree of twist and the flange combination.

The firm also manufactures complex waveguide components and assemblies.

Circle Reader Service Card 118

—*mwj*—

NOISE SOURCE FOR MICROWAVE TESTING OFFERED BY BOMAC



A compact, rugged X-Band gas discharge noise source, one of a wide range of new microwave components being offered by Bomac Laboratories, Inc., Beverly, Mass., is designed to measure the noise figure of receivers.

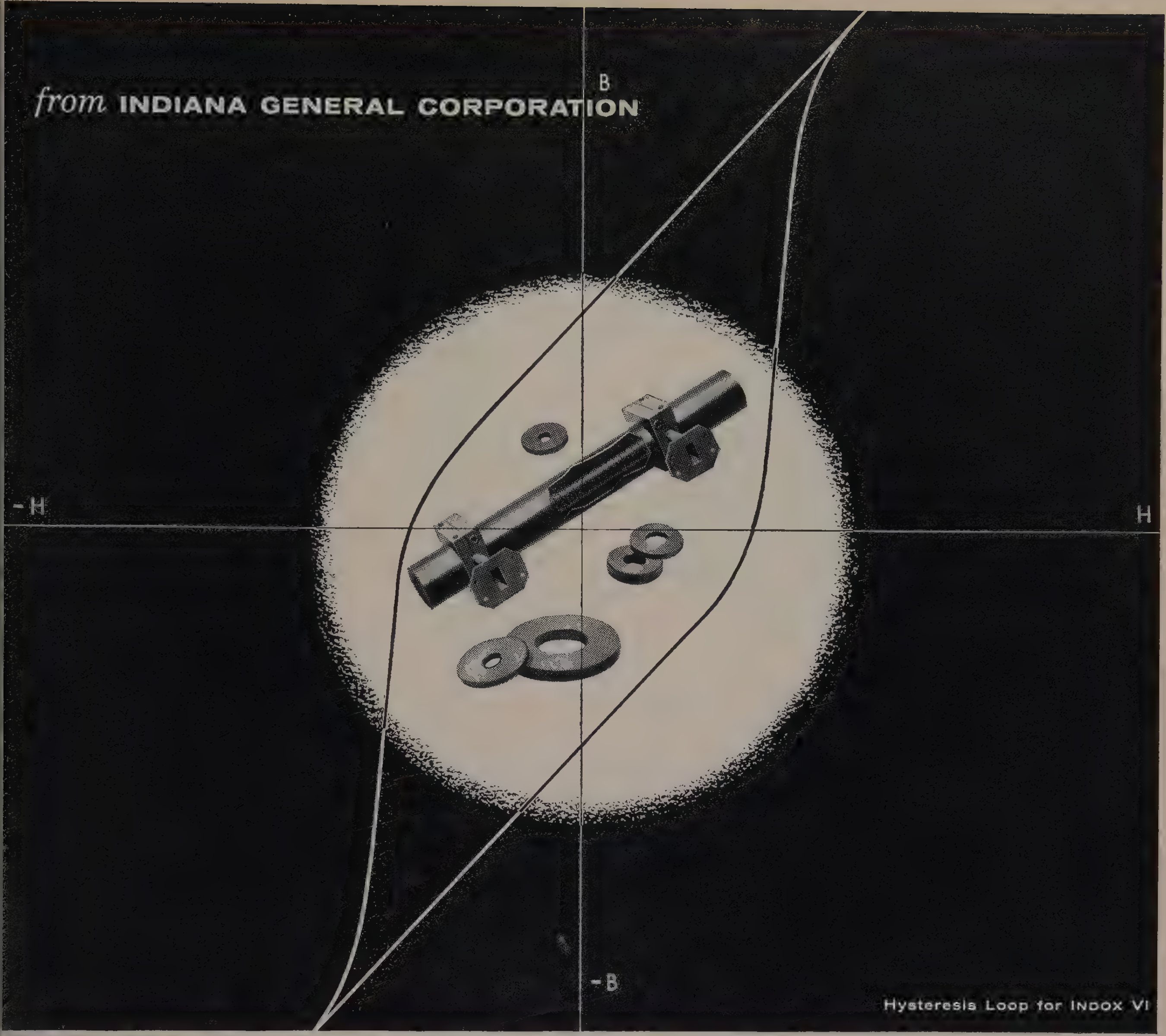
The termination, usually attached externally as an accessory, is included within the waveguide. The entire unit, exclusive of waveguide, is epoxy-resin potted to secure tube, leads, and other parts within the housing. High voltage BNC receptacles are used to connect a readily available limited current transformer to a 115 volt, 400 cycle power source. A dc power supply is not required.

The unit is also available in Ku-Band.

Circle Reader Service Card 119

—*mwj*—

(*Continued on page 116*)


from INDIANA GENERAL CORPORATION
B
-H
H
-B
Hysteresis Loop for INDOX VI

CREATIVE MAGNETICS

TO OUTFLANK MICROWAVE ROADBLOCKS

New magnetic materials, developed by Indiana Steel Products and General Ceramics Divisions, have led the way to simpler, more compact, better-performing microwave components.

The R&D team at Indiana Steel Products Division is meeting the challenge of new ideas in microwave equipment design. INDOX VI, one of several exciting new ceramic magnet materials, has permitted designers to reduce size, weight and cost of periodic focusing traveling wave tubes while improving performance. This material, with a typical coercive force of 2,550 Oersteds, has exceptional resistivity to demagnetization—just one of several properties that makes it ideal for TWT use.

And still the search goes on. Newly developed materials and component assemblies for microwave applications are now under test.

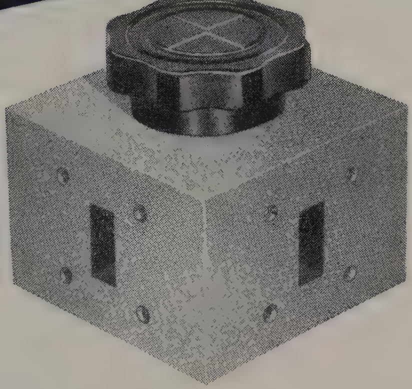
From our General Ceramics Division come exclusive gyromagnetic ferrite compounds for microwave devices such as rotators, resonance isolators, circulators, phase shifters and filters.

The microwave field is just one of many where Indiana General ferrites and permanent magnets have improved component performance. Our engineering and research staffs welcome the opportunity to offer assistance on your magnetic applications. We will be happy to send literature. Write us, stating your general areas of interest.

INDIANA GENERAL CORPORATION VALPARAISO, INDIANA

Permanent Magnets • Ferrites • Technical Ceramics • Memory Products • Magnetic Separation and Handling Equipment

Circle Reader Service Card 67



Waveguide Switches

Waveline precision Waveguide Switches are available in seven waveguide sizes to cover the frequency range of 3.95 to 40.0 KMC. These manually operated devices have been designed for applications in the laboratory or for microwave systems to make alternate connections between two waveguide inputs and two waveguide outputs.

Excellent electrical characteristics are achieved by unique precision and assembly techniques which Waveline has developed to provide the highest quality of microwave instruments. Full waveguide range operation is obtained with a VSWR of 1.10 maximum and an isolation greater than 60 db.

The switches are normally supplied with rotation in the narrow wall plane (circular bend of the rotor in the "E" plane) and are manually operated by means of a knob. Also available are "H" plane versions which are designated by suffix letter H.

Waveline Model No.	Frequency Range, KMC	Waveguide Type
378-E	3.95 to 5.85	RG-95/U
478-E	5.85 to 8.20	RG-106/U
578-E	7.05 to 10.00	RG-68/U
678-E	8.20 to 12.40	RG-67/U
778-E	12.40 to 18.00	RG-107/U (AL)
878-E	18.00 to 26.50	RG-66/U (AL)
1078-E	26.50 to 40.00	RG-96/U (AL)

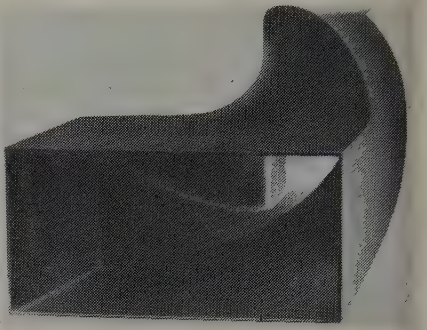
WAVELINE INC.
CALDWELL, NEW JERSEY
Phone: CApital 6-9100 TWX Caldwell, N. J. 703

Circle Reader Service Card 68

New Products

(*Continued from page 114*)

LARGE WAVEGUIDE TWISTS OFFERED BY KENT CORP.



The F. C. Kent Corp., Newark, N. J., is now producing large waveguide twists in standard L-Band tubing for use by the electronics industry in the low frequency range.

Special tooling and equipment installed at the firm, a subsidiary of Bart Manufacturing Corp., Newark, N. J., were designed to cold form the tubing with twist lengths of 18 inches and up.

Bronze tubing (Type RG-69/U) and aluminum tubing (type RG-103/U), having a cross-sectional area 6.660 inches by 3.410 inches, are being processed in the recently expanded facilities.

Both coaxial and offset twists have been made to the specifications of Kent's customers within the competitive price range of the industry.

Circle Reader Service Card 120

—mwj—

WATKINS-JOHNSON MODIFIES ITS ULTRA LOW-NOISE TRAVELING-WAVE TUBES

Watkins-Johnson Co., Palo Alto, Cal., has announced modification of its WJ-211 and WJ-212 ultra low-noise traveling-wave tubes to better satisfy customer requirements.

The improvement consists of changing from the Winchester MRE18P formerly employed to a Winchester M12P dc power plug. The modification results from improvements in tube design and construction techniques allowing high performance operation using only four anode voltages rather than the 11 anode voltages previously necessary. The changeover will reduce the complexity of power supply design by eliminating a voltage divider heretofore necessary.

Watkins-Johnson Co. states it is not expected that the improvement will present problems for customers presently operating W-J tubes in the field. Upon report of any problem, the company says it is prepared to supply an adapter for adjusting the new tube to existing equipment.

Circle Reader Service Card 121

—mwj—

(*Continued on page 118*)

WR-650 to WR-2300

HIGH PERFORMANCE WAVEGUIDE

Applied Microwave Electronics and Washington Aluminum Company announce a technical affiliation to provide industry with a comprehensive line of waveguide components. The high performance characteristics of this line of waveguide is produced economically, through the engineering competence and manufacturing know-how of Washington Aluminum and the advanced design techniques of Applied Microwave.

Straight Sections, VSWR 1.02

Bends, VSWR 1.03

Coax to Waveguide Transitions

Directional Couplers

Fixed Terminations

Sliding Terminations

Sliding Short Circuits

Taper Sections

Slotted Lines

Finned Waveguide

This added to our present proven antenna capabilities assures that we can accept systems responsibility for integration of all passive microwave equipment.

Direct inquiries to
Applied Microwave Electronics, Inc.
114 W. 25th Street
Baltimore 18, Md.

APPLIED MICROWAVE ELECTRONICS, Inc. / **WASHINGTON ALUMINUM CO., Inc.**
BALTIMORE, MD. BALTIMORE, MD.

Circle Reader Service Card 69

CHARLIE'S ANT(ENNA)

This is Charlie Creaser, President of ASI.

He couldn't get a new ASI 60-foot Antenna through the Coliseum doors, so he's done the next best thing.

He's brought himself, Bill VanderWolk, and Al Fowler and a carload or so of new literature on the subject for the edification of all who would be current on the current state of the art.

You'll find Charlie's Ant (ennas) at BOOTH 2009, SECOND FLOOR, SOUTH ROOM. SEE YOU THERE.

ANTENNA SYSTEMS INC.
HINGHAM, MASSACHUSETTS

◀ Circle Reader Service Card 70

New Products

(*Continued from page 116*)

MELABS OFFERS ULTRA MINIATURE S-BAND ISOLATORS

A series of ultra miniature, S-band isolators are now available from Melabs, Palo Alto, Cal.

The Model X-173 isolators are useful in missile and satellite applications and in replacing resistive pads.

Model X-173A, covering 2.6 - 3.3 kMc, has an isolation greater than 10 db with 18 db at band center. Model X-173B, 2.7 - 2.9 kMc, has an isolation greater than 14 db. Isolation of Model X-173C (2.95 - 3.25 kMc) is also greater than 14 db.

All three models have an insertion loss of less than 1 db, and a VSWR of 1.2:1.

Each isolator weighs only six ounces and 3½ inches long, including Type N connectors. Model X-173A is priced at $175; Models X-173B and X-173C are each $155. Delivery is from stock.

Circle Reader Service Card 122

—*mwj*—

HIGH VOLTAGE CIRCUIT BREAKER PRODUCED BY RESITRON

Resitron Laboratories, Inc., Santa Monica, Cal., has added a series of high voltage, high powered switching devices to its present product line.

The new units are characterized by fast switching time, low contact resistance throughout their life, and relatively small size for their power handling capability.

The new units were originally developed for plasma research work and are now finding widespread use in radar ground control, single side band equipment, high voltage power supplies and x-ray systems. They are capable of switching from 10 — 150 kv at currents up to 1000 amperes.

The new units can also be provided with a small variable solid-state circuit breaker which can be preset to a very broad range of currents for circuit protection. After a fault on current overload occurs the high voltage is disconnected from the system in less than six milliseconds. Reproduciability of the system for current fault detection is better than 1/2 of 1 per cent on all ranges.

Circle Reader Service Card 123

—*mwj*—

(*Continued on page 120*)

WESGO—*Quality leader in vacuum tube ceramics and brazing alloys!*

High alumina ceramics for vacuum tube envelopes, internal spacers, rf windows, heat sinks, high-voltage insulators ...*your* specific electronic application.

Ultra pure low vapor pressure brazing alloys—a complete range of melting points and wetting characteristics for any vacuum requirement; wire, ribbon, sheet, powder, preforms...

AND THE NEW WESGO POLYFORM

...a money-saving new form for brazing alloys. Obviates the waste in stamping, gives you totally new versatility, bends to the form you need. Valuable for R&D work, introduces new production-line economies.

"VX" Super Refractory, Wesgo ceramics with uniquely high resistance to thermal shock. Ideally suited for use in furnace brazing, available in boats, slabs, special brazing fixtures.

devoted to the manufacture of products of unparalleled quality... to meet the exacting requirements of the vacuum tube industry!

See us at IRE, Booth 4203

WESTERN GOLD & PLATINUM COMPANY
525 Harbor Boulevard • Belmont, California • LYtell 3-3121

6777

Circle Reader Service Card 71

SPERRY *Microline*®

31A1 AVERAGE POWER METER

AVERAGE POWER METER MODEL 31A1
Microline

NOW!

MEASURE POWER TO 3%

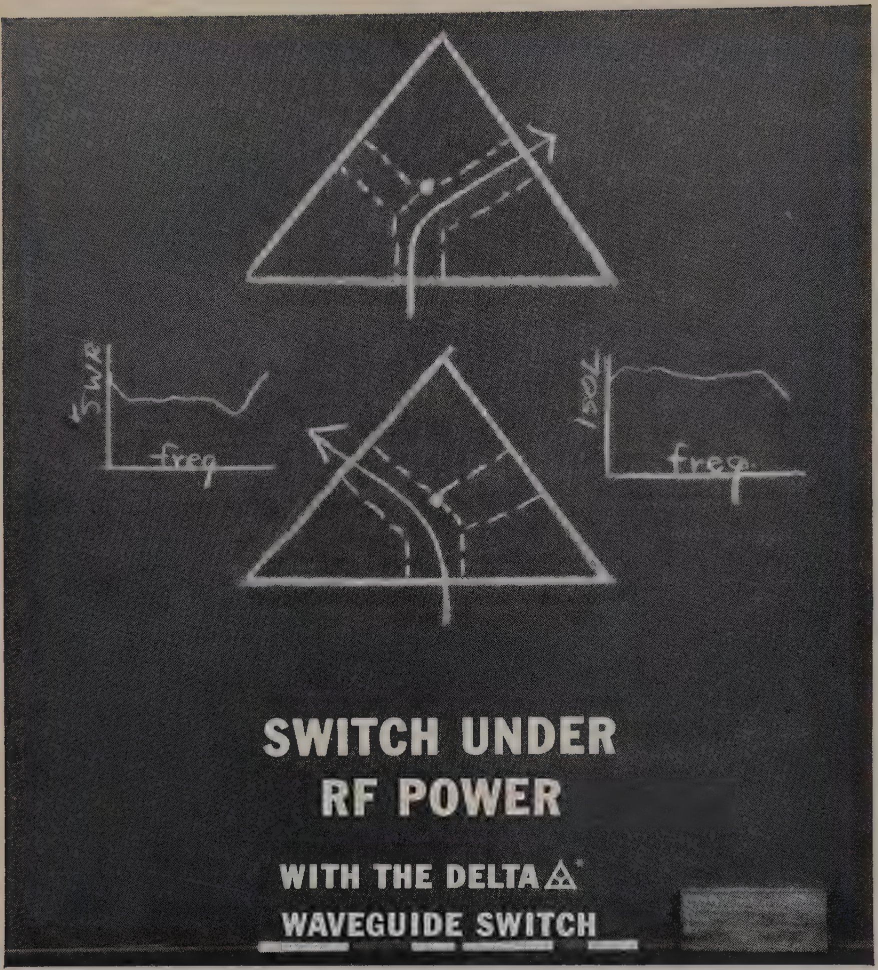
MOST ACCURATE instrument of its kind on the market. Has unmatched stability. Sperry Microline 31A1 can be used to measure pulsed or C-W power of radar, radio, television, microwave and microwave relay equipment and components. Priced competitively low.

EASY TO BALANCE. In addition, two scales (0-10 db and 5-15 db) permit its use for direct attenuation measurements. Its frequency coverage is limited only by the range of the bolometer and mount used. D-C bias adjustment is set by a 12-position switch.

Scales:	Five ranges, front panel selection: 0-.1, 0-.3, 0-1.0, 0-3.0, 0-10 milliwatts full scale. Two ranges 0-10, 5-15 db full scale. Higher power levels by using directional couplers and/or calibrated attenuators.
Accuracy:	3% of full scale reading.
Power:	105-125 volts, 210-230 volts, 50-60 cps.
Bolometer:	Temperature coefficient: positive or negative, front panel selected. Resistance: 100 or 200 ohms, front panel selected.
Bias Current:	0-16 ma d-c
Recorder Output:	0-1 ma, 1500 ohms, one side ground
Oscillator Frequency:	10.7 kc.
Weight:	Approximately 13 lbs.
Price:	$240.

SPERRY

SPERRY MICROWAVE ELECTRONICS COMPANY, *CLEARWATER, FLORIDA · DIVISION OF SPERRY RAND CORPORATION*



7 milliseconds switching time
7 ounces for x-band model
Operates in severe environments

A new concept in remotely-controlled microwave switching, DELTA △ Waveguide Switches permit 7 millisecond switching under rf power. Control circuitry to shut down magnetrons or other power sources may be *eliminated* in many systems. Switching under rf power is possible because the switching element is a thin metal vane which acts as a power divider during the switching cycle. The benefits—LIGHT WEIGHT, RELIABLE OPERATION and MINIMUM ACTUATOR POWER.

The DELTA △ W-6XA shown here is one of a complete line of rugged waveguide switches designed for reliable operation in critical environments. Write or call us or your Don-Lan Engineering Representative for complete specifications on these switches today.

actual size
(x-band)

Don-Lan Electronics, Inc.
a subsidiary of
Quantatron, Inc.
1131 Olympic Blvd.
Santa Monica, California
EX 3-0758

*PATENT PENDING

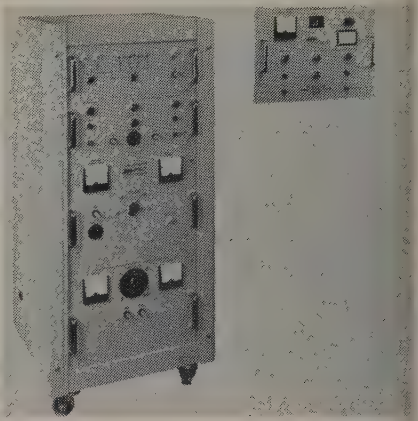
Don-Lan specializes in combining optimum microwave and electro-mechanical techniques. Consult us on your microwave electronic problems.

Circle Reader Service Card 73

New Products

(*Continued from page 118*)

MANSON REMOTE-CONTROL MODULATOR OPERATES UP TO 1000 FT.



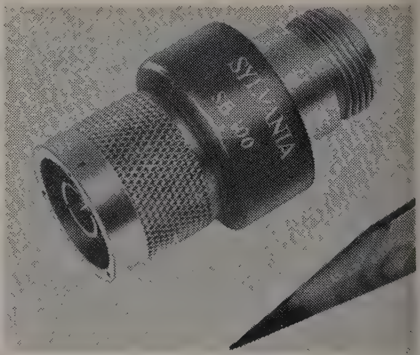
Manson Laboratories, Inc., Stamford, Conn., announce the development of a modulator that fills a need for remote-control monitoring.

This new modulator can be operated as an integral unit, or for systems remote in monitoring outposts as far as 1000 feet away. It provides continuous tuning of a magnetron and permits work from a tower. It is the latest in a series of new Manson developments in modulators, high voltage power supplies and communications instruments.

Circle Reader Service Card 124

—mwj—

SYLVANIA ANNOUNCES DEVICE FOR DC AND LOW-FREQUENCY ISOLATION

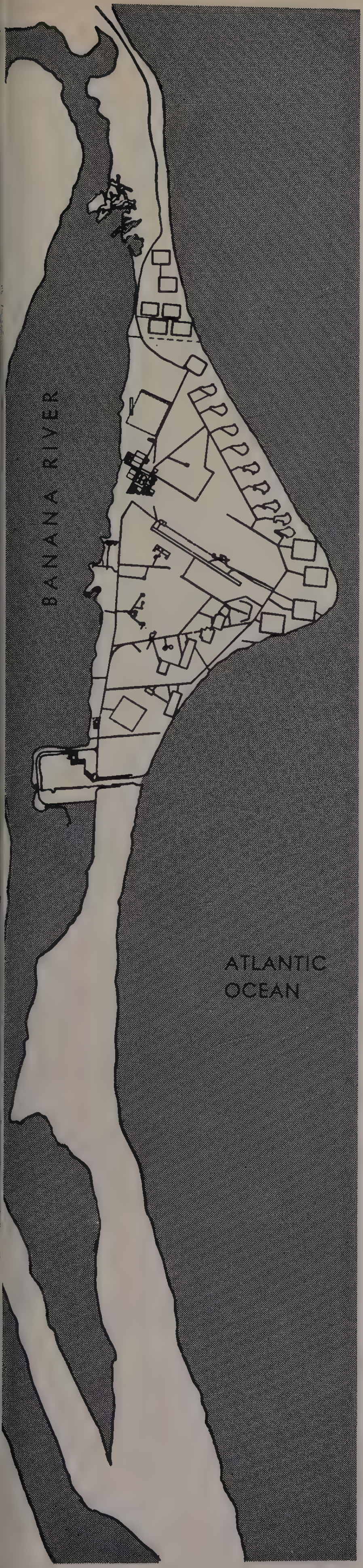


Sylvania Electric Products Inc., Mountain View, Cal., has announced the development of a wideband microwave device which promises to simplify the circuitry and improve the sensitivity of communications links, long-range radar and other advanced microwave equipment

Known as SB-100, the Sylvania coaxial component acts as a band-pass from 2.5 Mc - 11,000 Mc while isolating frequencies from dc to 2.5 Mc.

The new wideband low-VSWR unit will eliminate 60 cycle ground loop currents and provide dc and low-frequency iso-

(*Continued on page 122*)



"INTERDICT"

Silencing the Skies at Canaveral

...and what it means to you

Cape Canaveral, a serious r-f interference problem, and a group of experienced Capehart engineers. This was one salient phase in the operation we call "INTERDICT," for Interference Detection and Interdiction by Countermeasures Team. The exact nature and reason for this operation, and the engineering service that is now available to all r-f installations, comprise our story...

You probably already know of the r-f interference experienced at the Cape: the large number of radiating and receiving equipments there were creating undesirable field conditions. Origin of these conditions was unknown. Capehart's engineers were asked to analyze all the site's r-f sources—radars, telemetry links, communications equipment, etc.—and to predict and determine the interference sources. What they found is now history. Many of the spurious signals stemmed from higher harmonics of radar and communications systems. Once these had been defined and located, and other sources of rfi also isolated, the engineers of INTERDICT recommended ways to still the noise, so that the skies over Canaveral could be silenced.

Next: Vandenberg. After their mission at Cape Canaveral, the Capehart engineers were called to Vandenberg Air Force Base. Once again, r-f radiation was causing interference and hazard problems. Once again, the Capehart INTERDICT team went to work: performed field measurements, analyzed spurious signals for carrier frequency and source, analyzed instrumentation and all r-f equipments functioning at Vandenberg. As a result of Capehart's recommendations and countermeasures, the noise could be silenced at Vandenberg, too.

If you have site problems or r-f interference on any military or industrial communications-electronics equipments, the engineers from Operation INTERDICT are at your service. Their background in this field is unparalleled, and their experience and knowledge of all current types of equipment can now be offered to all. This is the first such service we know of, and we're proud to make it available.

Note: As you well know, interference and noise can come from a variety of sources. Spurious transmitter and receiver signals are close to inevitable in electronics installations of any complexity. Our function is to determine what is interfering with what, and to take the correct remedial action. We also perform diagnoses as to possible electromagnetic radiation hazards to personnel, squibs, ammo or fuel, and suggest the proper remedies for these hazards.

In short, Capehart's INTERDICT service is performed in compliance with all applicable MIL Specifications and systems requirements. INTERDICT, under the direction of Dr. Joseph H. Vogelman, offers you complete, world-wide, packaged services for the prediction, detection and elimination of r-f interference, personnel and material hazards. To learn more about these services contact:

Capehart® CORPORATION

INTERDICT GROUP, Dept. D, CAPEHART CORPORATION
87-46 123rd Street, Richmond Hill 18, New York • HIckory 1-4400

Circle Reader Service Card 74

CHANGE db VALUES OF ATTENUATION IN SECONDS!

STODDART'S **new** turret attenuators* offer quick change of db combinations compatible to your system requirements.

Simply remove three set screws and the pad retainer ring moves forward for easy replacement, removal or rearrangement of pads.

NET BENEFITS TO USER . . .

- Easy pad replacement eliminates downtime otherwise required for unit or equipment dismantling.
- No increase in price!

Patent applied for

16-page UHF Attenuator Catalog No. AT-3 gives complete details and specifications of new Stoddart attenuators, terminations and turret-type step attenuators.

STODDART
AIRCRAFT RADIO CO., INC.
6644 Santa Monica Blvd., Hollywood 38, Calif. HO 4-9292
serving 33 countries in radio interference control

Circle Reader Service Card 75

New Products

(*Continued from page 120*)

lation in 50 ohm coaxial systems. At frequencies of 2.5 - 11,000 Mc, insertion loss amounts to 0.2 db or less.

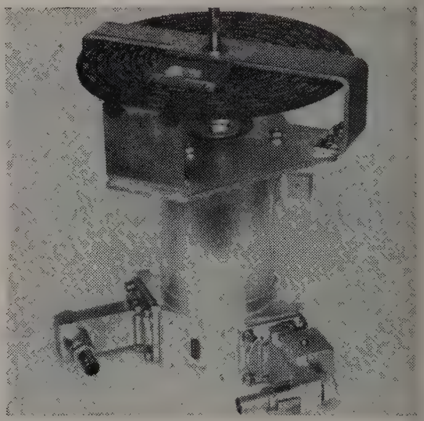
The new Sylvania device is made with N, BNC, or TNC coaxial connectors. It is available in three configurations: one providing dc blocking on both the inner and outer conductors, one with blocking on the inner conductor only, and one with blocking on the outer conductor only.

With inner and outer conductor blocking and Type N connectors, SB-100 is priced at $50. Types SB-101 and SB-102 at $55 have inside-outside configurations with BNC and TNC connectors, respectively.

Circle Reader Service Card 125

—*mwj*—

DUAL MODE DISCRIMINATOR DEVELOPED BY FREQUENCY STANDARDS



A new microwave dual mode discriminator has been developed by Frequency Standards, Asbury, N. J., for use as a sensing element in klystron frequency stabilization systems.

The discriminator is capable of furnishing an error signal with approximately 40 times the stability of the klystron alone. This signal is available over the entire range of the discriminator.

The accuracy of the signal frequency depends on the calibration accuracy of the discriminator cavity but accuracies of 0.01 per cent can be achieved.

The effect of stabilization in the range of 8500-9600 Mc is to reduce an inherent klystron signal variation of 0.6 - 1.2 Mc (a function of frequency) without stabilization, to variations of 15 - 30 kc with stabilization.

The discriminator also provides a substantial reduction in hum and other rapid fluctuations normally present in the klystron signal, and it reduces changes due to line voltage fluctuations to a negligible amount. Price range is $1200 to $1400, and delivery is 30 days.

Circle Reader Service Card 126

—*mwj*—

(*Continued on page 124*)

2 NANOSECOND MICROWAVE SWITCHING with SOLID STATE RELIABILITY

MA-3457
MICROWAVE ASSOCIATES

Microwave Associates' new coaxial switches provide:

- Efficient switching across the microwave spectrum
- Solid-state reliability for military applications
- Lightweight (approx. 5 oz.) ruggedized construction
- Low driving power — from 10 to 100 milliwatts
- Power handling capability {4 watts CW (S.P.S.T. unit) / 150 watts peak at 0.001 duty cycle}
- Low insertion loss — as low as 0.2 db

Solid-state switches are as good as the semiconductors they incorporate. All units described use the most advanced microwave silicon diodes available, specifically developed for this function by Microwave Associates Semiconductor Division.

LOW POWER LEVEL COAXIAL SWITCHES

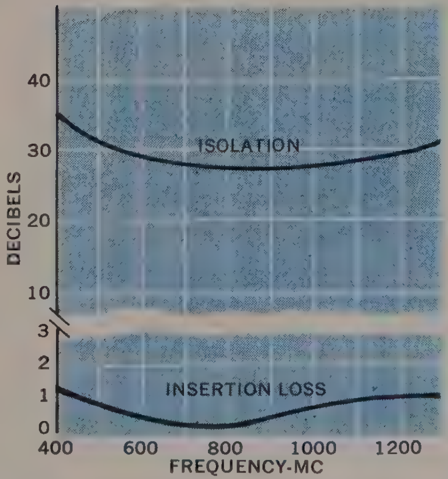
Frequency (Mc)	Insertion Loss (Max)	Isolation (Min)	Switching Power
210-240	0.2 db	20 db	10 mw
260-340	0.2 db	18 db	10 mw
400-500	0.3 db	20 db	10 mw
570-630	0.3 db	20 db	10 mw
900-1000	0.3 db	20 db	10 mw
1250-1350	0.5 db	20 db	10 mw
MEDIUM POWER LEVEL COAXIAL SWITCHES			
200-1000	1.5 db	22 db	70 mw
1000-2000	1.5 db	20 db	70 mw
2000-4000	2.0 db	16 db	70 mw

LOW POWER LEVEL VOLTAGE VARIABLE ATTENUATORS

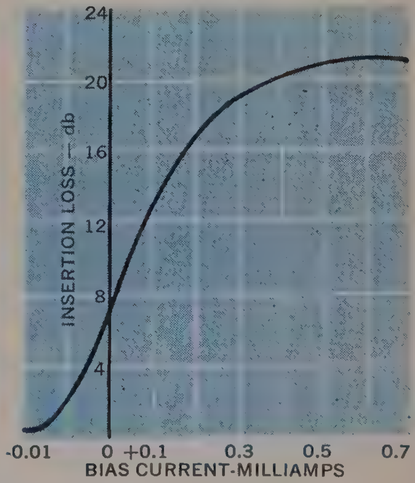
Frequency (Mc)	Attenuation Range
260-340	0.2 db-18 db
400-450	0.3 db-20 db
570-630	0.3 db-20 db
1250-1350	0.5 db-20 db

Narrow-band higher frequency units are available with lower loss and increased isolation.

TYPICAL PERFORMANCE BROADBAND MICROWAVE SWITCH SPST



TYPICAL PERFORMANCE VOLTAGE VARIABLE ATTENUATOR (425 Mc±25)



Units for handling higher powers are now in development. Microwave Associates has capabilities for meeting your requirements for single-pole multiple-throw and waveguide switching devices. Our switches invite comparison. We invite your inquiries. A quotation/data sheet will be sent on request.

MICROWAVE ASSOCIATES, INC.
ELECTRON TUBE AND DEVICE DIVISION, Burlington, Mass.
Western Union FAX • TWX: Burlington, Mass., 942 • BRowning 2-3000

A GOOD MAN NOWADAYS IS HARD TO FIND

Bill VanderWolk, for instance.

Like anybody who is anybody in the antenna field, he's exhibiting at the IRE show this year.

Problem is, finding the ANTENNA SYSTEMS, INC. booth without a road map.

We can simplify the problem. Just take the escalator to the second floor, turn left . . . and follow your feet until they won't go any further. That will be South Room.

That's where Bill is. Booth 2009. And where Bill is, you'll find Charlie Creaser and Al Fowler . . . plus all the latest on what's new in the antenna field.

BOOTH 2009. See you there.

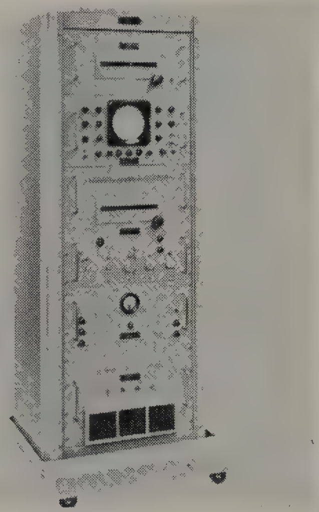
ANTENNA SYSTEMS INC.
HINGHAM, MASSACHUSETTS

◄ Circle Reader Service Card 77

New Products

(*Continued from page 122*)

POLARAD ANNOUNCES WIDEBAND SPECTRUM ANALYZER MODEL WSA



Polarad Electronics Corp., Long Island City, N.Y., has developed a wideband Spectrum Analyzer having a display of up to 4000 Mc.

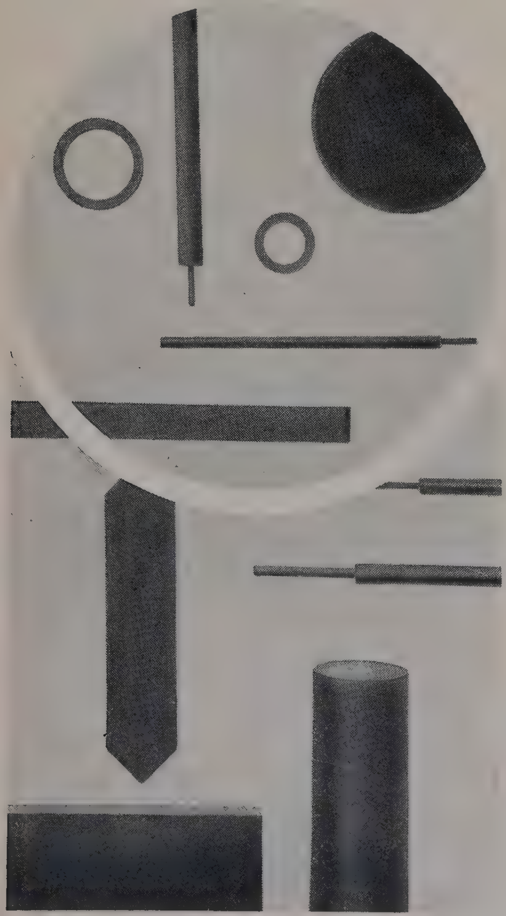
The Model WSA covers the frequency range from 10 Mc - 40,000 Mc in 20 bands which are contained in one unit. The extreme wideband display can be used to simplify field intensity measurements by displaying the entire range of each frequency band, for testing r-f transmitters and signal generators for "holes" throughout their tuning range, checking out broadband jamming systems, observing and measuring sidebands associated with modulated signals, and to determine pulse widths and pulse shapes by spectrum analysis techniques.

The unit features rapid band selection by illuminated push button switches; a frequency marker up to 4000 Mc; end-markers to indicate frequency limits of each band; a center-marker allowing the operator to switch from wideband to narrow band without hunting for the r-f signal; automatic fail-safe circuitry to protect backward wave oscillators; seven inch cathode-ray tube; synchronization either internal, line frequency, or external; dispersion 1 Mc - 25 Mc in narrow band and 50 Mc - 4000 Mc in wideband; resolution is 20 kc in narrow band and 1.5 Mc in wideband; sweep repetition rate is adjustable from 1 - 30 cps.

Circle Reader Service Card 127

—*mwj*—

(*Continued on page 126*)



microwave ferrites for defense

Low-loss ferrites offer high density, consistent uniformity

New pressing techniques now assure General Electric microwave ferrites of high density and consistent uniformity in both large and small production quantities. Developed for C-, S-, and X-band frequencies, these ferrites are available in five distinct compositions—each combining special characteristics to meet particular design requirements.

Composition 42L, for example, affords low dielectric losses and features low magnitudes of Tan Delta and saturation magnetization. Ferrite material 36L also exhibits a low Tan Delta, while further providing a high Curie temperature and a narrow line width of 90 oersteds.

Both these and other General Electric microwave ferrites are offered in a variety of shapes and sizes, including extruded tubes and rods for circular wave guides and coaxial transmission lines. Equally suited to operation at low and high power, they find important defense applications in such components as isolators, duplexers, and microwave switches.

For complete specifications, write to: Defense Industries Programs, Section 176-53.

GENERAL ELECTRIC

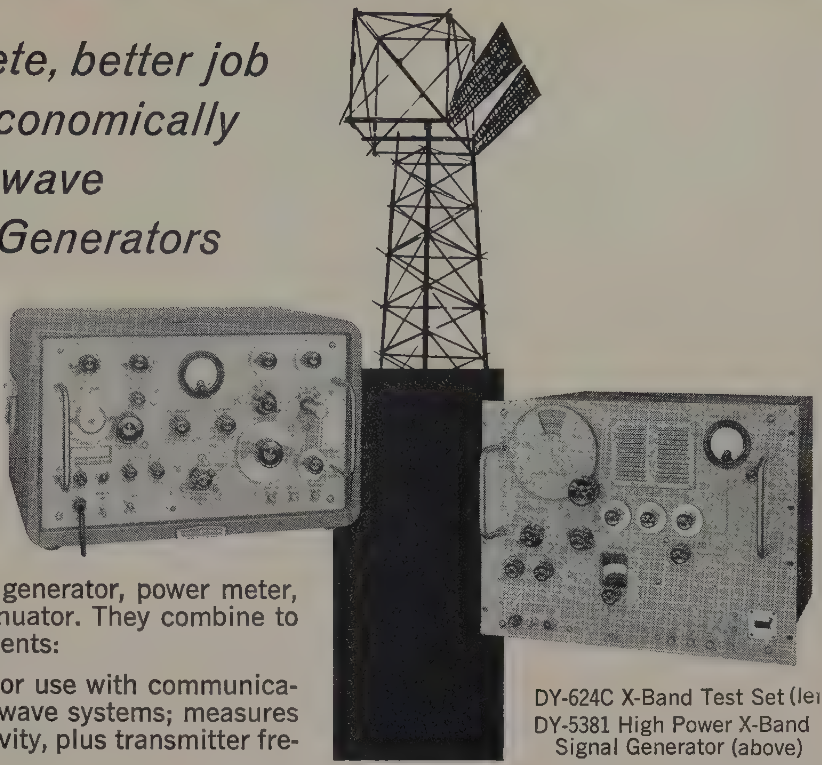
DEFENSE ELECTRONICS DIVISION
HEAVY MILITARY ELECTRONICS DEPARTMENT, SYRACUSE, N. Y.

Circle Reader Service Card 78

TEST, MAINTAIN MICROWAVE SYSTEMS?

Do a more complete, better job faster and more economically with Dymec Microwave Test Sets—Signal Generators

Dymec Microwave Test Sets and Signal Generators combine several basic instruments in one compact unit to give faster and more economical test and maintenance service for microwave systems.



DY-624C X-Band Test Set (left)
DY-5381 High Power X-Band Signal Generator (above)

Each test set includes signal generator, power meter, wavemeter and precision attenuator. They combine to meet a wide range of requirements:

DY-623B SHF Test Set, ideal for use with communications, control and video microwave systems; measures receiver sensitivity and selectivity, plus transmitter frequency and power level.

DY-624C X-Band Test Set, particularly useful for testing complete radar and fire control systems or radar beacon equipment.

DY-5003 X-Band Test Set, incorporates features of the DY-624C, has higher output power, more accurate attenuator, is protected against accidental application of high input signals.

DY-5381 High Power X-Band Signal Generator, provides minimum output of 250 milliwatts over its entire range, approximately 400 mw at band center; especially useful for testing radar systems through directional couplers. Also useful as parametric pump.

DY-5636 H-Band Test Set, covers the important microwave relay communications band, is particularly convenient for testing complete communications systems.

Brief specifications are presented here. Write your Dymec/Hewlett-Packard representative or contact us directly for complete information.

SPECIFICATIONS	**DY-623B**	**DY-624C**	**DY-5003**	**DY-5381**	**DY-5636**
Frequency Range	5925-7725 mc[1]	8500-10,000 mc	8500-10,000 mc	8500-10,000 mc	7125-8400 mc
Frequency Meter Range	5820-7780 mc	8500-10,000 mc	8500-10,000 mc	—	7125-8400 mc
Output Power	0 dbm (1 mw)	0 dbm (1 mw)	15 dbm (30 mw)	24 dbm (250 mw)	15 dbm (30 mw)
Output Attenuator Range	70 db	100 db	100 db	100 db	100 db
Internal Modulation	FM, 1 kc	Pulse, 35-3500 cps FM, power line frequency	Pulse, 35-3500 cps FM, power line frequency	Pulse, Square Wave, 35-3500 cps. FM, power line freq.	FM, 1 kc
External Modulation	FM, Pulse, Square Wave, 30 cps to 100 kc	FM, Pulse, Square Wave, 35-3500 cps	Pulse, FM, Square Wave, 35-3500 cps	Pulse, FM, Square Wave, 35-3500 cps	FM, Pulse, Square Wave, 30 cps to 100 kc
Power Measurement Range, CW	—6 to + 3 dbm	—6 to + 3 dbm	—6 to + 3 dbm	—	—6 to + 3 dbm
Price	$1,900.00 (transit case)	$2,265.00 (cabinet) $2,250.00 (rack mtd.)	$3,600.00 (rack mounted)	$4,835.00 (rack mounted)	$4,475.00 (transit case)

[1] 3 Klystrons needed for full range.

Data subject to change without notice. Prices f.o.b. Palo Alto.

DYMEC

A Division of Hewlett-Packard Co.

dy®

7018

See us at IRE Booth 3019-3020

395 Page Mill Road, Palo Alto, California

Telephone: DAvenport 6-1755 TWX-117-U

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THE LINCOLN LABORATORY
Massachusetts Institute of Technology

Lincoln Laboratory is supplementing its staff. The Laboratory is engaged in basic air defense research for the space age. This expanding program is a natural outgrowth of our advanced research and development in the fields of Radio Physics, Radar, Systems Studies, Satellite Surveillance, Computer Technology and Solid State Physics. Senior scientists are invited to join the Laboratory in solving urgent problems of importance to the defense of the United States.

The Laboratory is seeking qualified specialists in:

RADIO PHYSICS and ASTRONOMY
NEW RADAR TECHNIQUES
SOLID STATE PHYSICS and METALLURGY

- **A more complete description of the Laboratory's work will be sent to you upon request.**

Research and Development
LINCOLN LABORATORY
Massachusetts Institute of Technology
BOX 25
LEXINGTON 73, MASSACHUSETTS

New Products

(Continued from page 124)

TWT FOR 7-11 KMC RANGE DEVELOPED BY GE

A ruggedized, low-noise traveling-wave tube for use in the 7-11 kMc frequency range has been developed by General Electric Company, Palo Alto, Cal., for input service in radar receivers.

The metal-ceramic tube, designated Z-3103, has a noise figure less than 10 db, minimum gain of 25 db, and power output of 5 milliwatts across the entire band. It has been tested successfully to withstand shock at 50 g's and vibration at 5 g's.

Additional uses for the Z-3103 include applications in radio astronomy, radiometry, countermeasures and microwave relay systems. It also can be used as a limiter and automatic gain control tube or as a microwave mixer and frequency divider.

The Z-3103 is supplied as a complete package including permanent focusing magnets, connectors and housing. The assembly, which features coaxial input and output weighs 11.5 pounds and can be mounted in any position.

The tube, priced at $2850, is available within 30 days from the Power Tube Department.

Circle Reader Service Card 128

—*mwj*—

PULSE TRANSFORMER KIT AVAILABLE FOR PROTOTYPE DESIGN

PULSE TRANSFORMER KIT
PTK-1
ELECTRONICS DIVISION
HAMILTON WATCH COMPANY
LANCASTER, PENNA.

Six pulse transformers which offer over 20 different inductance values are included in a new Kit, PTK-1, now available for design engineers from the Electronics Division, Hamilton Watch Company, Lancaster, Pa.

The kit contains six ferrite core pulse transformers with standard 7 pin miniature plug-in bases for simplification of breadboard design of new circuits and prototypes where the exact transformer or inductor requirements are not known.

(Continued on page 129)

NEW CALIBRATED FIELD INTENSITY RECEIVER

POLARAD
PROVEN RELIABILITY

Now, in a single unit, the new Polarad Model FIM indicates the absolute power level of a radiated or conducted input signal by comparing it against an internally generated signal.

- Model FIM accurately measures frequency and absolute power level of microwave energy.
- Only Field Intensity Meter approved category A MIL SPEC under MIL-I-22600 at this frequency.
- Only microwave Field Intensity Receiver with self-contained signal generator which calibrates entire system under test at any level.
- First single microwave test system to determine r-f interference and susceptibility to interference.
- Front-panel meter indicates average, peak, slide-back peak or quasi-peak value of r-f signals. Outputs for video, audio and recorder.
- Four interchangeable tuning heads cover 1,000 to 10,000 mc.
- Direct-indicating peak VTVM for ease of frequency location of impulse noise.
- Single UNI-DIAL tuning control tunes both the receiver and signal generator.
- Calibrated antenna system includes an omni-directional broad band antenna and a separate directional antenna to match each tuning unit.

COMBINES SIGNAL GENERATOR AND RECEIVER IN SINGLE UNIT

1,000 to 10,000 mc*

*Two compatible tuning units under development will extend frequency to 20 kmc.

MAIL THIS CARD for specifications. Ask your nearest Polarad representative (in the Yellow Pages) for a copy of "Notes On Microwave Measurements."

DON'T MISS POLARAD
AT THE IRE SHOW
Booths 3301—3307

1234567

POLARAD ELECTRONICS CORPORATION:

Please send me information and specifications on:

☐ Model FIM Calibrated Microwave Field Intensity Meter

My application is

☐ Model SA-84W Universal Spectrum Analyzer (See reverse side)

My application is

Name

Title Dept.

Company

Address

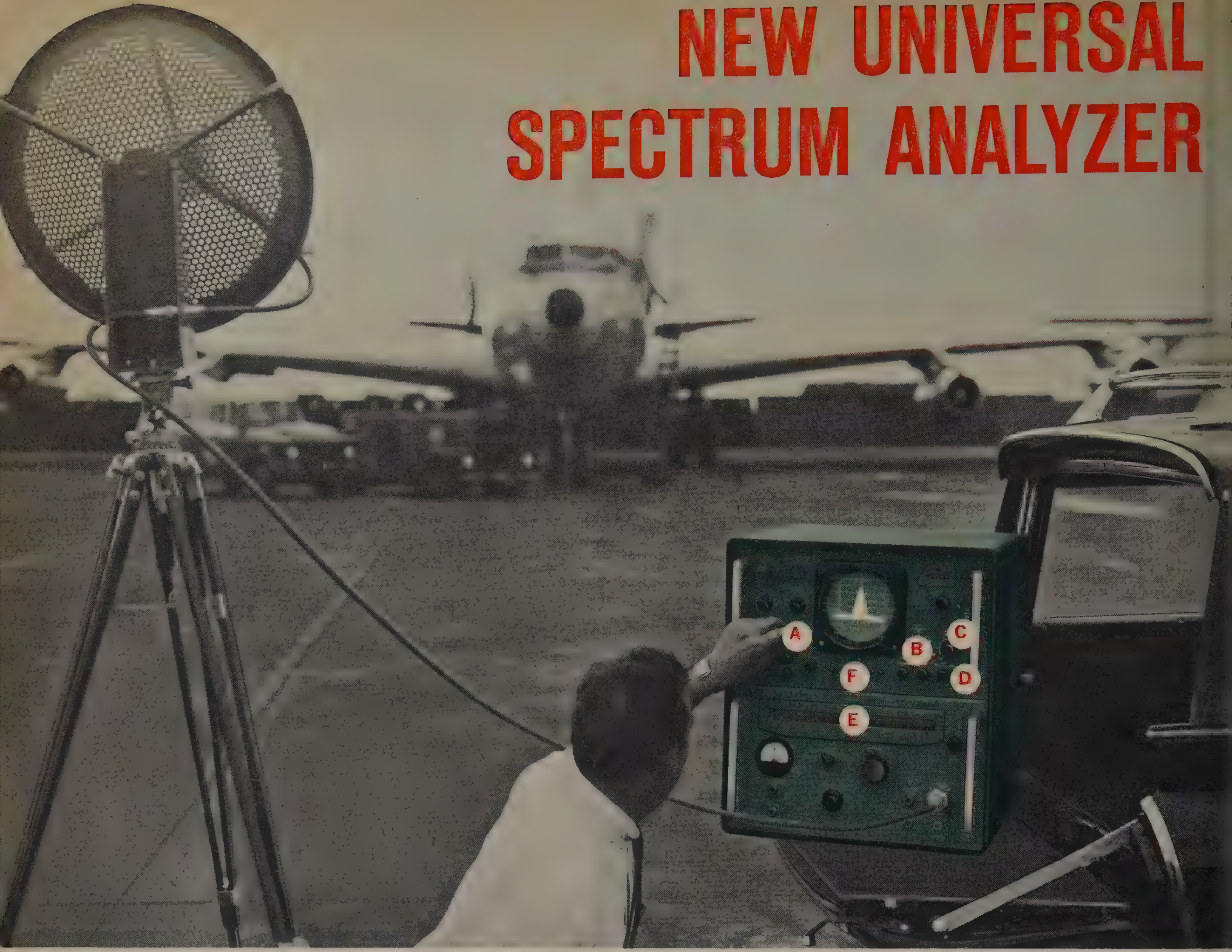
City Zone State

POLARAD
ELECTRONICS CORPORATION

FREE LIFETIME
SERVICE

43-20 34th Street,
Long Island City 1, N. Y.

NEW UNIVERSAL SPECTRUM ANALYZER



Polarad Model SA-84W being used to make pulse analysis of radar aboard a Pan American Boeing 707, Jet Clipper®

MODEL SA-84W 10 to 44,000 MC in a single unit

FEATURES:

- **Ⓐ Over 80 mc dispersion**
  1 mc to over 80 mc for narrow pulse analysis.
  100 kc to 7 mc for wide pulse analysis.
- **Ⓐ Dual Resolution**
  7 kc or 50 kc automatically set by dispersion control.
- **Ⓑ Crystal controlled markers from 10 to 44,000 mc.**
- **Ⓒ Provision for use with a multi-pulse spectrum decoder (Polarad Model SD-1)**
- **Ⓓ Log-linear amplifiers**
- **Ⓔ Expanded, direct-reading, slide rule dial.**
- **Ⓕ Accurately calibrated IF attenuator**

The Polarad Model SA-84W is the most accurate universal microwave analyzer to measure nearly all parameters — Pulse, CW, FM, VSWR, antenna patterns, bandwidths and filter characteristics.

MAIL THIS CARD for specifications. Ask your nearest Polarad representative (in the Yellow Pages) for a copy of "Notes on Microwave Measurements."

FREE LIFETIME SERVICE

POLARAD
ELECTRONICS CORPORATION
43-20 34th Street, Long Island City 1, N.Y.
Representatives in principal cities.

Postage Will be Paid by Addressee

No Postage Stamp Necessary If Mailed in the United States

BUSINESS REPLY CARD
First Class Permit No. 18, Long Island City 1, N.Y.

POLARAD ELECTRONICS CORP.
43-20 34th St., Long Island City 1, N.Y.

New Products

(*Continued from page 126*)

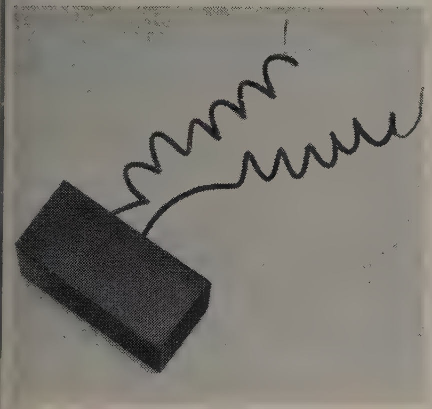
Individual pulse transformers have nominal open circuit primary inductances of 0.5, 1, 2, 5, 7.5 and 10 millihenries. All have turns ratios of 3 : 2 : 1, with secondary and tertiary rise times of less than 0.1 microsecond. They are insulated to withstand potentials of 500 volts and are designed to operate over a temperature range from −55°C to +105°C. For moisture resistance, the transformers are completely encapsulated in epoxy resin.

The six pulse transformers, 3/4 inch in diameter and 3/4 inch seated height, are packaged in a transparent plastic case for convenience and portability. The price of the complete kit is $25.

Circle Reader Service Card 129

—*mwj*—

CEC'S TELEMETERING FILTERS WEIGH 1 OZ.



Control Electronics Company, Inc., Huntington Station, N. Y., has introduced a line of telemetering filters that are miniaturized to meet requirements for missile or airborne telemetering systems.

Totally encapsulated, the units measure 23/32 inch x 23/32 inch x 1 3/8 inches long and weigh only 1 ounce.

The filters are available with center frequencies from 1.7 kc — 70 kc (Std. I.R.I.G. Freq.) with an impedance of 51 K ohms. Attenuation characteristics are less than 3 db at ±7 1/2 per cent and more than 20 db at ±27 per cent of the center frequency.

All units are entirely encapsulated per MIL-F 18327A Grade 5 and in addition to meeting other rugged environmental specifications, have an operating temperature range of −30°C to +90°C. The filters have three 6 inch Teflon insulated color-coded leads and are available with or without mounting studs. Delivery is from two to three weeks.

Circle Reader Service Card 130

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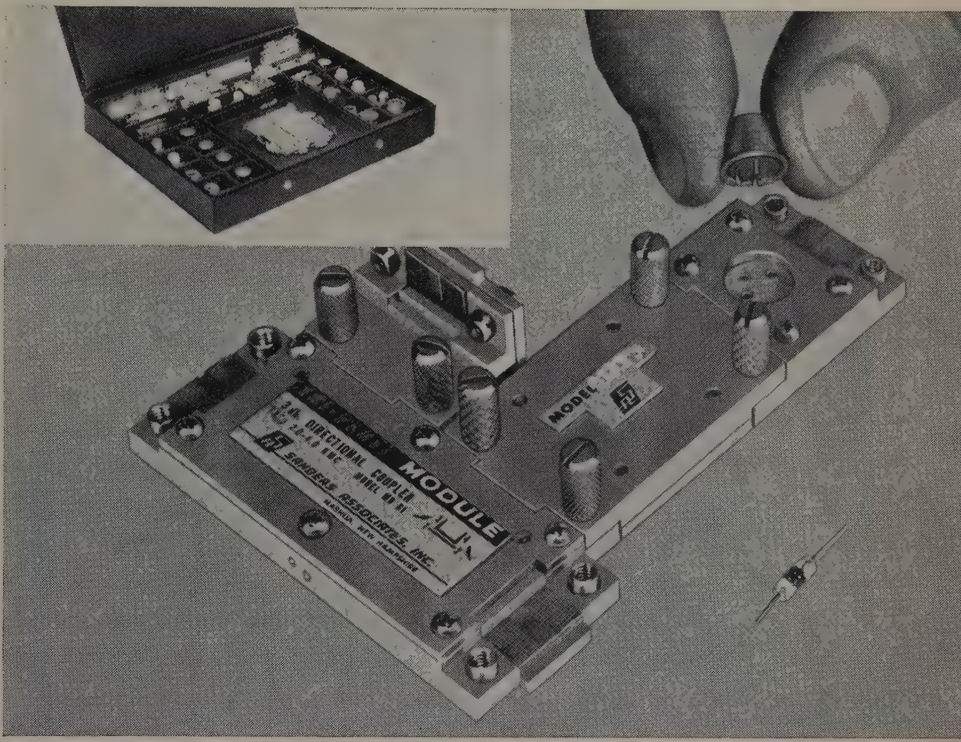
(*Continued on page 137*)

NEW KITS SPEED BREADBOARDIN
OF ADVANCED VARACTOR, TUNNE
DIODE AND TRANSISTOR CIRCUITS



Harmonic generators, parametric amplifiers, oscillators, pulse amplifiers and down convertors are now assembled in minutes with Sanders TRI-PLATE® *Modules!*

This new dimension in semiconductor circuit design offers nearly limitless combinations. In a matter of minutes complete circuit subassemblies using series or shunt 1, 2, 3 or 4 port mounts with choice of RF bypass, ground return and/or bias provision can be constructed.

Sanders new TRI-PLATE semiconductor mount kits accommodate 11 of the most commonly used semiconductor device packages. Such configurations as series, double ended cartridges, pigtail diodes, TO–18 and TO-5 transistor packages and ceramic cartridges are merely place in one of the various TRI-PLAT semiconductor mounts.

The new Sanders TRI-PLATE semi conductor mount kits extend an supplement standard TRI-PLAT strip transmission line module kit for sub-nano-second switching speed as fast as 7 KMC.

For complete specifications an prices of off-the-shelf kits of TRI PLATE semiconductor mounts an other reliability-proven modules write today.

® Sanders Associates, Inc.

See us at Booth No. 1723 — IRE Show

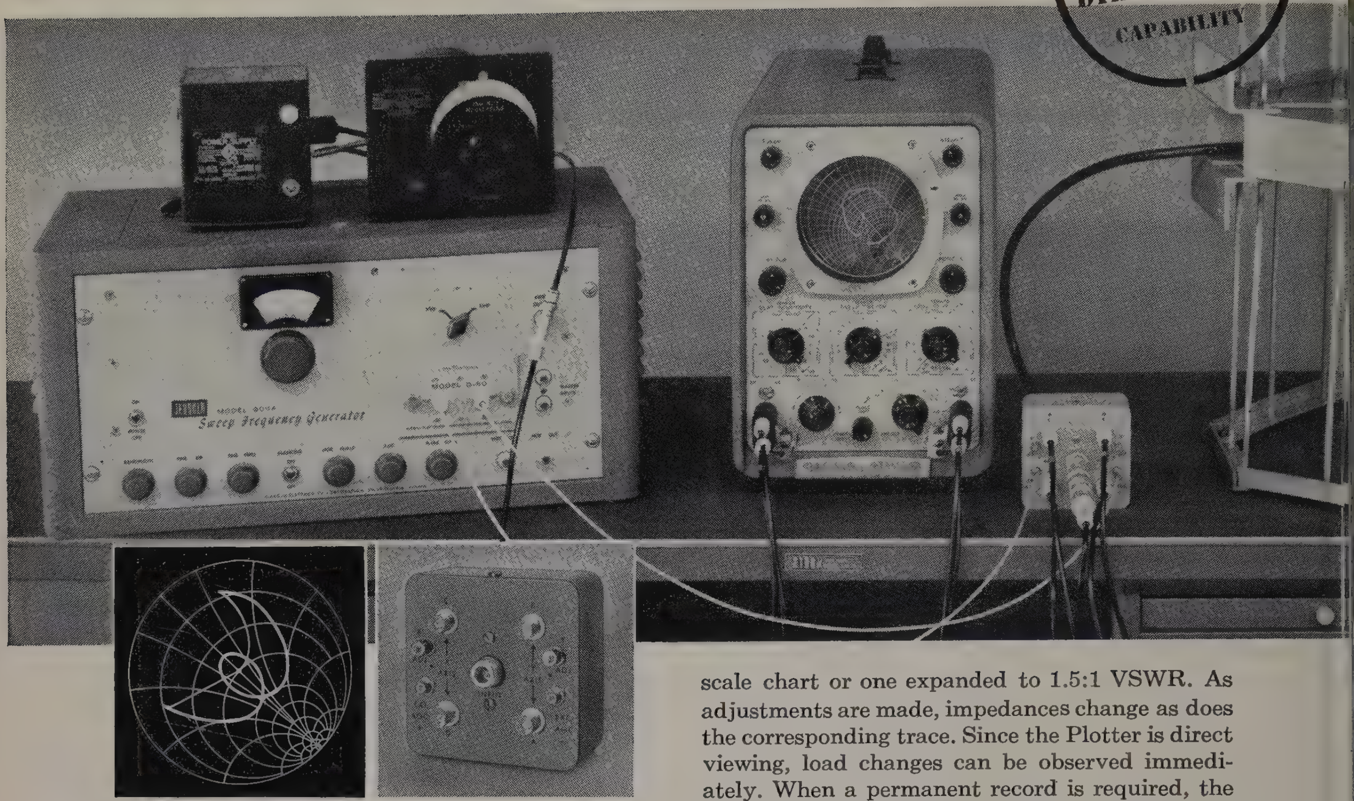
SANDERS ASSOCIATES, INC.

Product Manager, Microwave Products Dept., NASHUA, NEW HAMPSHIRE

Circle Reader Service Card 80

The best way yet to measure complex impedances

ANOTHER
MEASURE OF
DIELECTRIC'S
CAPABILITY



Here — for the first time — is an approach to the measurement of complex impedance over a band of frequencies that, for speed, simplicity and reliability, surpasses anything yet used.

It's the Smith Chart Plotter, specially developed by Dielectric Products Engineering Company to obtain instantaneous display of impedance as a continuous function of frequency. There are five coupler models spanning 10 to 3000 mc/s.

This unique coupler — along with appropriate auxiliary equipment to form the complete plotter — eliminates the need to tie up highly skilled technical personnel during prolonged test routines that characterize slotted line measurements. As precise as it is versatile and easy to operate, the Plotter functions simply and quickly to deliver peak accuracies.

HOW IT WORKS

With Dielectric's Smith Chart Coupler, a sweep generator sweeps over the frequency band of the unknown load. A continuous trace of impedance versus frequency is displayed directly on the Smith Chart faceplate. This can be either a full scale chart or one expanded to 1.5:1 VSWR. As adjustments are made, impedances change as does the corresponding trace. Since the Plotter is direct viewing, load changes can be observed immediately. When a permanent record is required, the oscilloscope trace may be directly photographed. Or, if preferred, an X-Y chart recorder may be used.

If you're a designer looking for a faster, easier way to obtain more accurate impedance and admittance measurements of diverse components such as antennas, filters, load resistors, transformers and other r-f networks, you'll find the Smith Chart Plotter one of your most essential tools.

For complete description and for details of operation of the Smith Chart Plotter, write for Bulletin 60-3.

SPECIFICATIONS (ALL MODELS)

Nominal impedance	50 ohms
RF input voltage	0.2 volts, rms
Oscillograph signal voltage	
(0.1 volt input to plotter)	40 millivolts x reflection coefficient
Accuracy of reflection coefficient measurement	
a. Amplitude	± 5% of reflection coefficient ± 0.01
b. Phase	$\pm$ 3 degrees $\pm$ arc tan $\left(\frac{.01}{\text{reflection coeff.}}\right)$
Sweep rate (maximum)	60 sps
Spot rotation rate (maximum for full accuracy)	1000 rev/sec
RF input and output terminals	Type N female
Oscilloscope signal terminals (balanced)	Type BNC female
Automatic level control terminals	Amphenol Series 27 female

Other areas of **DIELECTRIC** capability in coaxial, waveguide and open wire techniques . . .

TRANSMISSION LINE & COMPONENTS • NETWORKS
SWITCHES • TEST EQUIPMENT • R&D ENGINEERING

dial DIELECTRIC
for solutions to
communications
problems.

DIELECTRIC PRODUCTS ENGINEERING CO., INC.

RAYMOND, MAINE

See the Smith Chart Plotter in operation during the IRE Show, Booth 2004.

Circle Reader Service Card 81

Transmitting antenna at Goldstone.

JET PROPULSION LABORATORY

Pasadena, California

Introduction

About 25 years ago, Professor Theodore von Karman of the California Institute of Technology found a remote site in the San Gabriel Mountain foothills northwest of Pasadena where he could, undisturbed and undisturbing, conduct fundamental experiments in rocket propulsion. These early experiments led to the successful demonstration and subsequent development of jet-assisted take off for airplanes (JATO). Soon thereafter Professor von Karman and his rocket research group christened themselves and their remote rocky domain the Jet Propulsion Laboratory (JPL), a Division of the California Institute of Technology. In the decade that followed, JPL worked on a variety of pioneering rocketry and upper atmosphere research programs including the Wac-Corporal, which, in 1949 was launched in flight from a V-2 rocket to establish the then World's altitude record of 250 miles. In 1949 the Corporal upper atmosphere research vehicle, a 20,000 lb thrust scaled up version of its little sister Wac-Corporal, was selected by the Department of the Army for development as the Nation's first guided missile weapons system.

With the advent of the Corporal program, a considerable increase in number of personnel and size of facilities became necessary, and increased emphasis was placed on other facets of the missile art besides rocketry. By 1958, when JPL became a part of the National Aeronautics and Space Administration, the Laboratory had developed an impressive record of successful accomplishments in all branches of the missile and space vehicle field. Although JPL now works directly as a part of the NASA organization, the overall administration and employment is by Caltech. The Laboratory is now chartered by NASA to provide the technical guidance and administration of the NASA unmanned lunar and deep space exploration programs and the associated research activity in support of those endeavors. Under this charter, the Laboratory does much of its program work under subcontract to industry, maintaining its in-house technical capability to work on appropriate advanced problems and to provide capable technical administration of its subcontracted work.

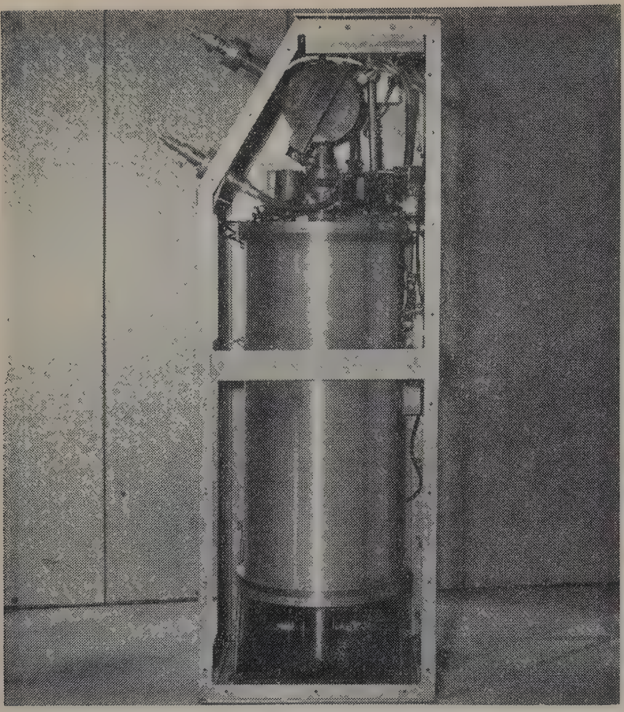
Much of the antenna and microwave work in the telecommunication division at JPL is concerned with the deep space instrumentation facility and its three stations. Of these stations, two, one at Goldstone, California and one at Woomera, Australia are operational. The third station in South Africa is presently under construction.

Birth of the Antenna and Microwave Group; the Communications Elements Research Section

During the early phases of the Corporal program, to support the needs of in-flight telemetry instrumentation, JPL became involved in a modest amount of antenna and rf component work. In 1951 the Antenna Group was formed, initially starting out with two engineers and two technicians. From this modest beginning, the Antenna Group (now the Antenna and Microwave Group) has steadily grown to its present size of a dozen people. Late in 1957 other related activities on the Laboratory were consolidated into the Communications Elements Research Section, which is directed by Robertson Stevens, one of the engineers of the original Antenna Group. Four research and engineering groups comprise the Section: the Antenna and Microwave Group, the Antenna Structures and Optics Group, the New Circuit Elements Group, and the Servo and Control Group.

The Antenna and Microwave Group has continued its activities in antenna and passive rf component research and engineering under the direction of Karl Linnes and more recently under Philip Potter, both of whom had participated in much of the group engineering work in the past.

A great deal of pioneering work in semiconductor rf



Experimental 960 megacycle Maser designed and built by Jet Propulsion Laboratory for use on the Goldstone receiver site antenna.

circuitry and low noise amplifiers has been done in the New Circuits Elements Group. Much of the group's highly successful efforts were sparked by the late William Pilkington's technical insight and enthusiasm. In the summer of 1960, Bill and his family were killed in an airplane accident. Dr. Walter Higa, who had been doing original work in the maser field under Bill, is presently directing the New Circuit Element activities in the fields of ultra low noise amplifiers and related systems, and the techniques of vacuum deposited circuitry.

The Antenna Structures and Optics Group under William Merrick maintains varied interests in the field of design, construction and instrumentation of large antennas. Their complement of ten people bring the Communications Elements a variety of background experience, from inertial gyroscope platform research to design work on the 200 inch Palomar telescope.

The Servo and Control Group which was formed in the summer of 1960, is led by Harold Richards. Richards was head of the Mechanical Design Department at the Caltech Cooperative Wind Tunnel until it was recently shut down in deference to the space age. The primary activity of this group is associated with the large and complex drive and control systems for the radio telescopes used in the JPL Space Vehicle Communication Systems.

Despite its broad range of interests, Communications Elements maintains a vestige of unification by working on common projects in the laboratory and in the field, and in smoke-filled conference rooms. Brainstorming is an accepted policy, and an effort is made to cross-fertilize between the many diversified disciplines within the Section. The activities of the Antenna Structures and Optics and Servo and Control Groups are somewhat peripheral to the present subject and will not be discussed in much detail; however, their close presence provides an almost unavoidable hue of engineering reality to the world of a JPL electromagnetic researcher.

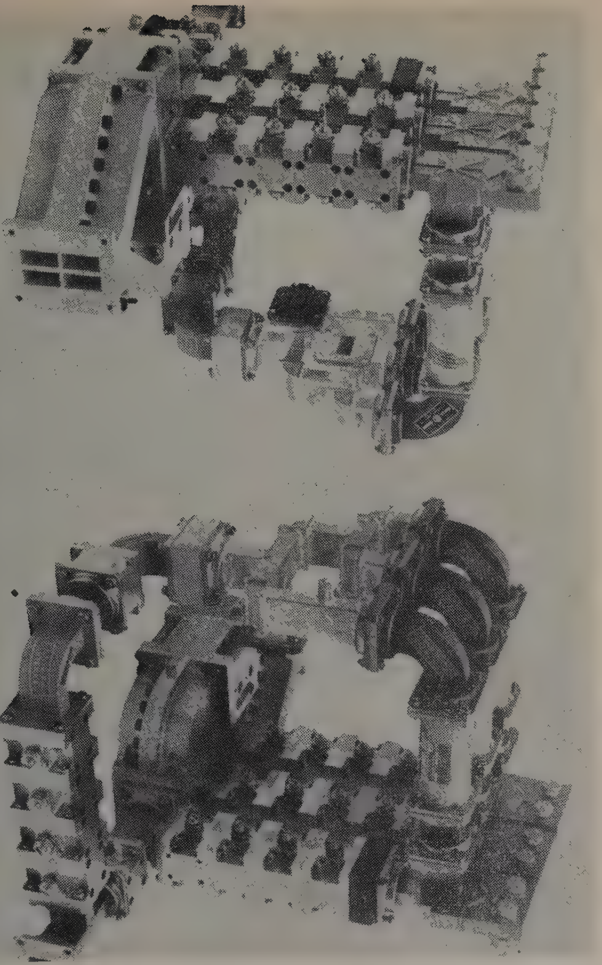
Antenna and Microwave Activities in the JPL Missile and Spacecraft Programs

The roots of antenna and microwave work at JPL developed in the late forties and early fifties in connection with the Loki, Corporal and Sergeant missile programs. Early airborne antenna work primarily involved design and testing of radar beacon telemetry and doppler antennas for these missiles. Ground antennas were involved as a part of conical scan radar tracking systems and VHF/UHF doppler systems. An existing radar was modified and used in the Corporal program, giving JPL antenna people valuable field experience at White Sands Missile Range. In this way the concept was developed of research and development engineers testing and operating their own equipment in the field. The Corporal program experience with the engineering problems of mechanically scanned tracking systems led naturally into a program of research and development in the field of ultra-high precision simultaneous lobing tracking systems, an area in which JPL still is actively engaged.

In 1955 JPL and the Army Ballistic Missile Agency at Huntsville, Alabama, became interested in the possibility of injecting a small artificial satellite into orbit around the earth. Studies were conducted in application of the ultra sensitive phase coherent receiving technique, developed by Dr. Eberhardt Rechtin, W. K. Victor, W. F. Sampson and others at JPL, to the realm of satellite communications and tracking. Out of these studies came the vhf system called Microlock with a receiving sensitivity of 10^{-18} watts. The Microlock system utilized an interferometer system of JPL designed helix antennas to provide launch phase angular information as well as launch and inflight telemetry. The vehicle transmitter presented a real technical challenge since anticipated payload weights did not permit the use of vacuum tube components, and transistors at that high a frequency were still essentially laboratory curios. Effort was immediately brought to bear toward realizing high efficiency in rf semiconductor circuitry. This effort bore fruit in September, 1956, when a JPL Microlock station successfully tracked a ten milliwat fully transistorized beacon to a distance of more than three thousand miles on the first Jupiter-C re-entry test vehicle missile firing.

Shortly after the launching of Sputnik I in October, 1957, JPL and the Army Ballistic Missile Agency were directed to put a small satellite into orbit with the Jupiter-C vehicle. An 80 day crash effort was undertaken to design new transistorized circuitry along the lines used in the 1956 firing and to design a new antenna system for the Explorer I satellite. During this period, JPL antenna engineers became painfully aware of the problems of highly expedited environmental design and testing. Their efforts paid off in January, 1958, however, with the completely successful launching of America's first satellite, Explorer I.

Although JPL participated in a series of Explorer launchings, the communications development work was done prior to Explorer I. Therefore, immediately after the Explorer I mission, major effort was brought to bear on the communication problem for lunar distances. JPL's deep space communication system philosophy was founded at this time after a detailed study of what turned out to be primarily an antenna problem. Largely on the basis of ground and vehicle antenna consideration the L-Band



Ultra-precision X-Band monopulse tracking feed bridge designed for high stability under field conditions.

region was chosen for the lunar probe communication frequency. Following assignment of a two vehicle lunar probe program to JPL-ABMA, studies were undertaken to determine the maximum vehicle antenna gain which could be utilized and still provide good coverage to the ground station during the entire cis-lunar flight of the spin-stabilized probe. An unsymmetrically fed conical antenna was chosen as the type which best fitted the constraints of pattern coverage, weight, size and environmental design. This conical antenna was used on the Pioneer III and IV vehicles. Pioneer IV was America's first, and as yet, only successful lunar probe.

Early in the Pioneer program, work commenced toward establishing a low noise site near JPL for a deep space tracking station. Based on a noise survey and careful study of terrain geometry, the site was established at Goldstone Dry Lake in the Mojave desert near the city of Barstow. At the same time, a detailed evaluation of existing large antenna designs began. An 85 foot equatorially mounted design was selected as most closely fitting the deep space tracking and communications requirements. A contract was made with the Blaw-Knox Company for fabrication and erection of the antenna and preparation of the Goldstone site was commenced. In order to prepare for the assignment of tracking Pioneer III in December, 1958, it was necessary to work three shifts at Goldstone during the late summer and fall of that year.

The basic method of feeding the 85 foot antenna for simultaneous lobing operation in the Pioneer program was developed at JPL. Exhaustive secondary pattern tests were performed at 1/10 scale to verify the design concept before the full size antenna was available. A contract was let to the Collins Radio Company of Cedar Rapids to design and fabricate two of these feed units for the Goldstone Antenna.

During the on-site construction of the 85 foot diameter antenna, the Structures and Optics Group worked closely with the erection sub-contractor (Radio Construction Company of Pittsburgh, Pennsylvania) to provide for the maximum possible accuracy in the erected structure. After the completion of construction and installation of the feed system detailed optical and rf tests were performed to establish the system tracking accuracy. During this period JPL engineers became familiar with the practical problems of making pattern and boresight measurements on large antennas. Antenna patterns sometimes had to be taken by sitting in the structure and manually controlling a valve in the hydraulic servo system. But despite all the problems and difficulties the Goldstone station was completed as originally planned and successfully used for tracking Pioneer III on December 6, 1958.

During 1959, several new uhf antenna feeds were designed and fabricated for the Goldstone equatorial mount antenna by the Rantec Corporation of Calabasas, Calif. Using these feeds, JPL has since participated in the tracking of a variety of space probes and satellites.

The current vehicle antenna development work at JPL centers about the Ranger program. For the Ranger, an attitude stabilized spacecraft was designed and is being built at JPL. Ranger can perform lunar fly-by missions or carry a rough-landing lunar capsule. A two-way L-Band communication system has been designed for Ranger to provide wide-bandwidth data transmission from the spacecraft as well as two-way coherent doppler and Earth command capability. A steerable high gain antenna is used on the spacecraft to provide data transmission to Earth. The command capability is realized by an essentially omnidirectional antenna mounted on the forward end of the spacecraft. JPL engineers are faced now, for the first time, with a new revolting problem in vehicle antenna design: getting almost omnidirectional pattern coverage on a large spacecraft which has no metal skin but is instead a conglomeration of metal struts, erecting booms and odd-shaped instrument packages. Just to make the problem interesting, an extremely sensitive magnetometer unit aboard the craft precludes the use of many materials commonly used in antenna construction.

Just around the corner lies participation in the problems of spacecraft antennas for more advanced lunar exploration vehicles (the Centaur boosted lunar soft-lander, Prospector) and the planetary exploration vehicles, Mariner and Voyager, etc.

Antenna and Microwave Activity in Advanced Communication Experiments

From time to time personnel at JPL become engaged in a large scale communications experiment which draws upon all of the various involved technical disciplines and invariably includes Antenna and Microwave Group representatives. Project Echo is a recent example of such a program.

NASA's Project Echo was an experiment in the use of a passive reflecting satellite for long-range communications. The program involved the placing of a 100 foot

Jet Propulsion Laboratory antenna range facility during construction phase, Christmas 1960.

metallized balloon into a nearly circular orbit around the Earth. A joint communications experiment between the Bell Telephone Laboratories on the East Coast and JPL's Goldstone Station on the West Coast, using the Echo balloon was performed. In preparation for this effort, substantial modifications had to be made to the Goldstone facility. In addition to the already existing 85 foot polar mount antenna, a second 85 foot altazimuth mount antenna and its supporting facilities were installed approximately seven miles from the original installation. A ten kilowatt CW S-Band amplifier was installed on the altazimuth antenna, to provide one end of the West-to-East Communication link.

The two sites have become known as the Transmitter Site and the Receiver Site. It is significant that the complete installation of the Transmitter Site with antenna, drive system, control building, electronic equipment, new antenna feeds, intersite communications and data transfer, and logistic support changed from naked desert to operational status in less than one year.

In order to adequately prepare the Goldstone facility for Project Echo a number of preliminary system tests were performed using the powerful CW radar capability. The moon was used as as passive reflector for L-Band signals from BTL to Goldstone and for S-Band signals from the Transmitter Site to both BTL and to the Receiver Site. Using the East-West links, good quality moonbounce telephone conversations were carried out between JPL and BTL. In addition, depolarization and related propagation experiments were carried out on the moonbounce signal.

To further prepare the Goldstone Station for Echo, tests were performed in skin tracking the Tiros I satellite. In the initial attempts, difficulty was experienced in getting sufficiently accurate orbital data to bring Tiros within the 1/3 degree antenna beams. However, by considerable perserverance, the problems were solved so that reliable acquisition and tracking of the Tiros was achieved. The moonbounce communication and Tiros tracking tests were effective in preparing the station for the Echo experiment during which the Goldstone antenna facility was successfully used to help demonstrate the feasibility of transcontinental passive satellite communications.

Sundry Activity in Antennas and Microwaves

Accidental Ignition of Electric Squibs — Various missile programs at JPL have resulted in a number of peripheral microwave studies being performed to answer program-generated technical questions. Early in 1956, for example, the question of accidental rf ignition of squib devices arose in connection with the Jupiter-C vehicle. A modest program both analytical and experimental in nature was undertaken in the Antenna and Microwave Group to determine the rf threshold of these devices, the safest missile wiring procedures and countdown safety precautions. Experimental tests were made at the Atlantic Missile Range in Florida prior to firings to determine actual in situ safety factors.

High Accuracy X-Band Tracking Antennas — In 1955 work commenced on an ultra precision X-Band simultaneous-lobing system. The goal was to produce a tracking system with a solid tenth milliradian accuracy in the field under all of the involved environmental conditions. The results of a detailed error analysis dictated the requirements for microwave "plumbing" and indicated that a precision machinist with a sufficient quantity of brass block stock and lots of patience could just barely do the job. Fortunately, all of these things were available at JPL and the system performed acceptably. The JPL obsession with accurate tracking systems is still present on a larger scale at the Goldstone facility.

Advanced Vehicle Antennas — JPL is maintaining an active interest in advanced or beyond the state-of-the-art antenna systems. Such bizarre devices as erectable balsa wood dishes have been built and even environmentally tested. Vehicle attitude determination on the ground by electromagnetic means is being studied. Recently, an experimental antenna with a modulation — "colored" radiation pattern was built and is proving a promising concept. The Laboratory also supports contractors who have promising novel ideas in the vehicle antenna line. Presently both Sanders Associates of Nashua, New Hampshire, and Space Electronics Corporation of Glendale, California, are performing studies for JPL in this area.

Ground Antennas For Space Communications — Deep Space communication is dependent on large aperture high gain ground antennas and ultra-low noise receiving systems. These factors determine the maximum tracking range and the information bandwidth for communicating scientific information. With the development of operational low-noise maser receivers, the antenna noise and the excess noise of the transmission line (connecting the antenna feed and the receiver) have become major contributors to the system noise level. Because of the importance of a low system noise level, a theoretical and experimental investigation of low-noise antennas is being conducted as a part of a program to continuously upgrade the JPL communication system capability.

Low noise antenna feeds and transmission lines have been tested recently with a 960 Mc maser receiver on one of the Goldstone 85 foot diameter paraboloids. An antenna temperature of 17° kelvin, exclusive of losses, has been measured with one feed system. This was measured at night, with the antenna pointed at the zenith and away from the galactic plane. The lowest noise feed system may result in a decrease in antenna gain, however. The best feed for the purpose of space communication may result in a slightly higher antenna temperature and a higher gain.

One of the most popular pastimes among communication system designers these days is to play with the radar range equation and derive "optimum" deep space communications systems. JPL has participated in this game and has concluded that most of the answers one seeks are contingent upon the vehicle and particularly ground antenna size and quality. For this reason an active program exists at JPL to attack the problem of realizing large high quality antennas for a reasonable cost. Attacking the problem from the mechanical side, the Antenna Structures and Optics Group maintains close contact with people throughout the world who are working on big antennas. In addition, they use the Goldstone structures as a proving ground for new ideas and techniques in the area. Working on the other side of the question, the Antenna and Microwave Group is doing analytical work to relate such things as dish surface tolerance to antenna electrical performance. As a side effort in this line, effort has been devoted to the effect of atmospheric inhomogeneities on antenna efficiency.

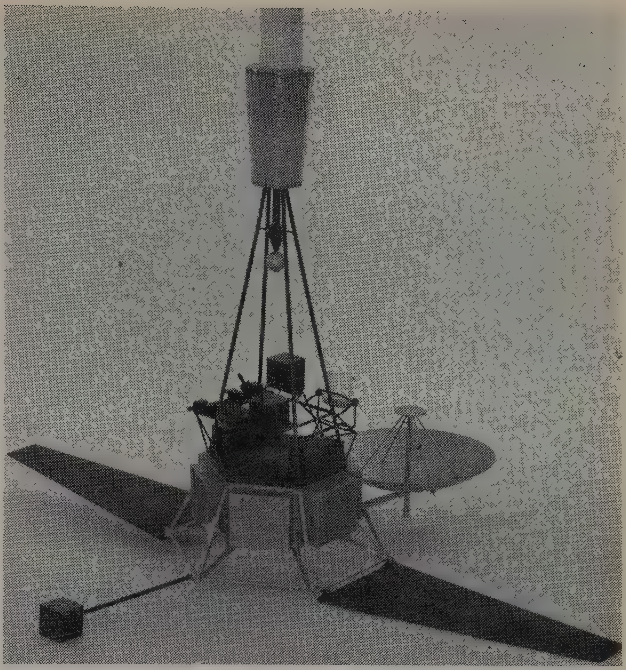
Low Noise Amplifiers—Work in the maser field at JPL began in 1955 when Dr. Walter Higa was assigned the task of designing a portable ammonia maser for missile guidance applications. This project led to the first successful sealed-off maser using liquid nitrogen to "pump" the ammonia gas. Realizing the need for sensitive receivers in space communications systems, efforts were shifted in 1958 from ammonia masers to solid state masers. This project led to the development of a prototype 960 Mc ruby maser which was successfully tested at Goldstone on the 85 foot antenna in October, 1960.

Dr. W. Higa, Dr. T. Sato, and C. Stelzried were principally responsible for the design, installation and testing of the L-Band maser. Total system noise temperature, including the contribution from the maser, antenna, line losses, and calibration equipment, was measured at 65 to 75° K, depending on the antenna feed used. The homemade dewar was particularly successful and provided an operational life of 36 hours per filling of liquid helium (3 liter capacity). The engineers, however, are quick to admit that the success of the project was possible only through the skilled assistance of three technicians, R. Clauss, K. Wallace and E. Wiebe, who among other duties, devotedly serviced the maser 75 feet off the ground.

To augment the maser work, a parallel research effort under Stelzried is directed at optimizing parametric amplifiers. This work has so far led to an exceptionally stable laboratory model amplifier utilizing very low impedance cavities.

Current activities in the low noise area include prototype development of an S-Band maser system for a radar experiment this spring. Subsequently field operational masers for the JPL Deep Space Instrumentation Facility will be designed and constructed in conjunction with an industrial contractor.

Theoretical studies in maser and related devices are being carried out by Dr. Willard Wells who has extended theories of Prof. Richard Feynman and Prof. E. Wigner to the quantum mechanical treatment of Masers.



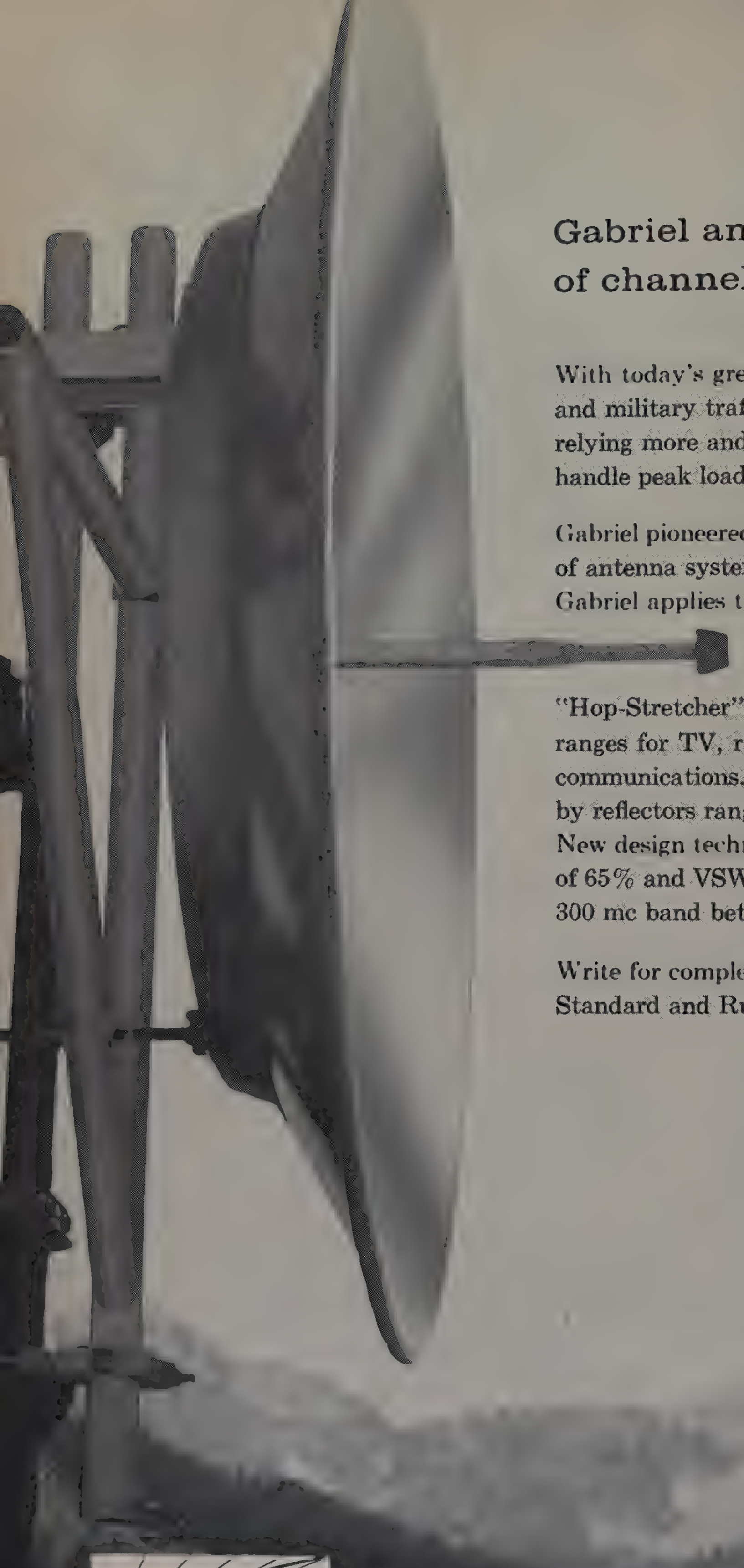
One-quarter scale model of the Ranger Spacecraft used for antenna radiation pattern tests.

Antenna and Microwave Facilities

Instrumentation, one of the worst problems that plagues space communications systems designers and analyzers, is nailing the antenna people down on the performance of their devices. At present, JPL antenna engineers are working hard to get better measurements on all fronts, from the high gain Goldstone dishes to the omnidirectional vehicle command antennas. Their goal is to achieve experimental measurement accuracies comparable to those obtained on the other components of the rf system.

An extensive multipurpose antenna range facility is under construction on a mesa-like area immediately north of the Laboratory. Natural terrain provides an almost ideal situation for both the over the canyon type of range and the flat, controlled geometry type. Visualized as a half-million dollar facility by 1962, the complex will achieve the unusual situation of having one complete range per research engineer. At the present time five of these are reality. A 50 foot range with a small azimuth rotator provides for tests on small high frequency antennas such as are encountered in scale model spacecraft studies. For somewhat larger models and large antenna feed studies, a two axis dielectric tower rotator designed and fabricated by the Blain Electronics Corporation of San Fernando, California, is used on a track system to provide detailed calibration of multipath errors. A large azimuth rotator and wooden tower are emplaced at the edge of a natural valley to provide a 400 foot range for antenna evaluation of full-sized spacecraft models weighing a thousand pounds or more. High gain antenna patterns are measured on a 584 radar mount emplaced at one edge of an 800 foot wide canyon.

A parallel range using a modified Nike pedestal is used for boresight and related tests on high gain monopulse systems. At Goldstone, where far field distances range up to tens of miles, new measurement techniques are being evaluated and tested to further the state-of-the-art.



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New Products

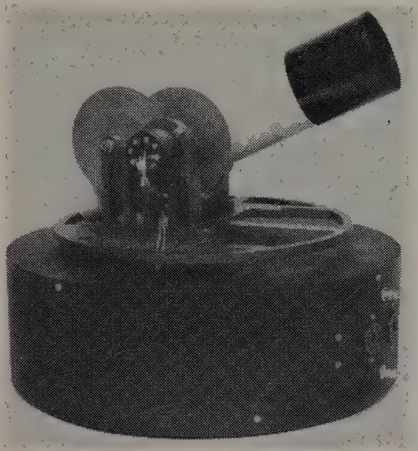
(*Continued from page 129*)

ELECTRONIC SCANNING STAR TRACKER ANNOUNCED

ITT Laboratories, Fort Wayne, Ind., announces the availability of an all electronic scanning star tracker which eliminates all mechanical aperture movements.

The ITT Electronic Scanning Star Tracker is capable of tracking sources in the visible and near-infrared regions with a one inch diameter objective lens down to levels equivalent to a sixth magnitude star with a tracking rate of one radian per second.

The tracking telescope is a compact unit containing an optical system, the ITT FW-118 phototube, and electronic circuitry. All of the electronic circuits except the servo amplifiers and power supplies may be contained within the unit. The telescope may be gimbaled to track from a stabilized base or it may be fixed direct to the vehicle. The star sensor weighs only two pounds and occupies 35 cubic inches.



Typical applications of the electronic scanning star tracker are satellite and space vehicle attitude control; space vehicle guidance; tracking of missile exhaust plumes; tracking balloon satellites, and automatic sextant for aircraft navigation; etc.

Complete technical specifications and price information available on request.

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—*mwj*—

DIPLEXER USED FOR HIGH POWER SCATTER SYSTEMS

Antenna Systems, Inc., Hingham, Mass., announces a new diplexer — Model 77-001 — for 755 to 985 megacycles. Its main advantage is that it is very easy to adjust and is set for operation easily and quickly.

The VSWR is less than 1.03, the pass band insertion loss is less than 0.1 db, and the reject attenuation is greater than 75 db.

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(*Continued on page 138*)

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MICROWAVE

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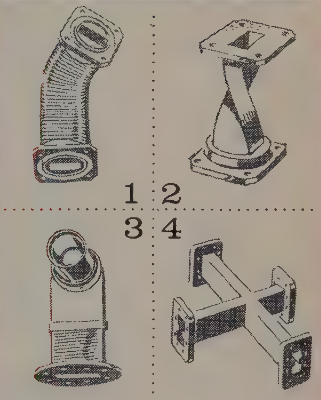

1 **FLEX WAVEGUIDE ASSEMBLIES**
Electrical Characteristics
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Attenuation .... 0.16 db/ft.
VSWR .... 1.08 max.
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Weight .... 1.002 lbs./Ft. (bare)
Operating Pressure ..... 30 PSIG max.
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Flanges .... Plate (UG-419/U)
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2 **RIGID WAVEGUIDE ASSEMBLIES**
ID Size Range .....From 0.420 x 0.170 to 6.50 x 3.250
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VSWR .... <1.2:1
Insertion Loss .... <0.25 db
Coaxial Impedance ...... 50 ± 2 Ohms

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Frequency Range .... 4.7 to 11.0 kmc
VSWR 1.4:1
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New Products

(*Continued from page 137*)

DOLPHIN INTRODUCES ATTENUATOR

By calibrating 110 individual points from 0 to 50 db, accuracy and resolution are assured in a new direct reading variable X-band attenuator introduced by Dolphin Inc., Stamford, Conn. This makes possible direct readings to an accuracy of 0.2 db. The actual insertion loss of each instrument is stated on its serialized name plate so that both absolute and relative attenuation measurements are possible.

This attenuator is the result of a new approach to the problems inherent in the design and production of precision variable attenuators and features low VSWR and low insertion loss. The actuating mechanism is inherently rugged and stable and has exceptional mechanical repeatability which assures accuracy within the instrument. A high degree of visual resolution is achieved by the use of a scale over 40 inches long and a maximum separation between calibration points of only 0.5 db. A metallized glass plate is utilized for stability.

Priced at $167.50, this attenuator is available in any one of five standard frequencies in the range of 8.2 kMc to 12.4 kMc at no extra charge.

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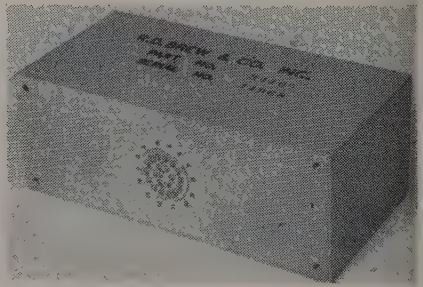
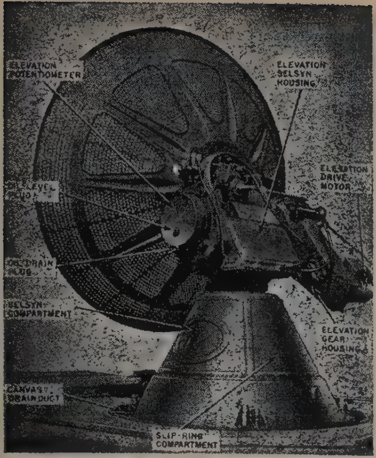
—mwj—

DELAY LINES USED FOR IFF EQUIPMENT



A new group of high performance delay lines for use in IFF equipment, has been introduced by the Richard D. Brew and Company, Inc., Concord, N. H.

This network has a total delay of 20.3 usec ±.05 usec, with taps available at every 1.45 usec. A minimum delay-to-rise time ratio of 100:1 has been established for these units by incorporating specially wound toroidal inductors with Q's in excess of 300, and stabilized mica capacitors. The characteristic impedance is 470 ohms,



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Full azimuth and elevation sweeps. 360 degrees in azimuth. 210 degrees in elevation. Accurate to 1 mil. or better over system. Complete for full tracking response. Angle acceleration rate: AZ, 9 degrees per second squared EL. 4 degrees per second squared. Angle slewing rate: AZ 20 degrees per sec. EL. 10 degrees per sec. Angle tracking rate: 10 degrees per sec. Includes pedestal drives, selsyns, potentiometers, drive motors, control amplidynes. Excellent condition. Quantity in stock for immediate shipment. Ideal for missile & satellite tracking, antenna pattern ranges, radar systems, radio astronomy, any project requiring accurate response in elevation and azimuth.
Complete description in McGraw-Hill Radiation Laboratory Series, Volume 1, page 284 and page 209, and Volume 26, page 233.

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and attenuation is less than 2 db. Spurious signals are maintained below —20 db. Operating temperature range is —55°C to +85°C. The delay line illustrated above has case dimensions of 8½ inches x 4½ inches x 3 inches. Mechanical characteristics can be varied provided an equivalent volume is available.

Other electrical characteristics may be established to meet special customer requirements. Delivery within four to six weeks can be made on the above described unit.

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—*mwj*—

MONOPULSE ANTENNA PATTERN SIMULATOR DESIGNED BY RANTEC

Rantec Corp., Calabasas, Cal., has recently completed the design of a Monopulse Antenna Pattern Simulator in the 5.4 - 5.9 kMc range which will perform a checkout or system analysis on monopulse circuitry and computers without the use of expensive range equipment.

This externally controlled unit, consisting of waveguide and ferrite components, simulates the signals normally derived from sum and difference circuitry by using an electronically driven microwave assembly.

The simulator provides adjustable electrical line lengths in both signal and local oscillator branches, and includes branching circuits with ferrite isolators and three balanced mixers.

Similar units are available in other frequency ranges.

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—*mwj*—

FXR ANNOUNCES TEST SET

The High Power Electronics Division of FXR, Inc., Woodside, N. Y., has released details on their new, 5 Megawatt Positive Grid Region Test Set. FXR's High Power Electronic Division is a designer and manufacturer of super high power electronic systems, sub-systems and test sets. This test set can be used for the design, development and production Quality Control testing of high power triodes and tetrodes whose test operating parameters fall within the wide ranges offered.

All voltages necessary for the testing of these high power tubes are produced internally in the Test Set. Full protection of both the operating personnel and the costly components undergoing tests is assured by use of interlocks, overload devices and lead shielding. As a further safeguard, a "panic button" is strategically located.

The Test Set has built-in provisions for both water and air cooling. All controls and panel indicators, including a wide band oscilloscope are mounted on an integrated series of panels.

Circle Reader Service Card 136

—*mwj*—

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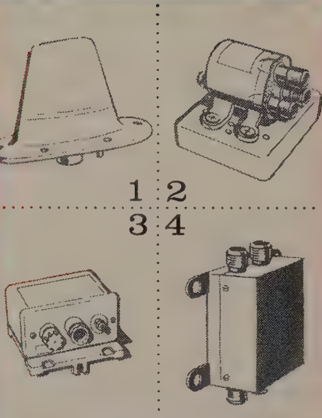

1 **L-BAND ANTENNA LB—247 — Designed for F-104**
Range .... 960 to 1220 mc
VSWR .... <1.7:1
Power .... 2 kw (peak)
Polarization .... vertical
Qualification MIL-A-25708
Weight .... < 8 Oz.

2 **MINIATURE CO-AXIAL SWITCH CS—319**
Power Handling ....200 W cw - 3 kw peak @ 0.1% duty cycle
RF Voltage .... 1000 min.
Operating Voltage .... 18 - 30 vdc
VSWR .... 1.2:1 max. to 1250 mc
Insertion Loss .... 0.2 db max.
Isolation ...... 40 db down to 1250 mc
Qualification MIL-S-25878

3 **ANTENNA SELECTOR RY—472G**
Switching Rate .... 70 ± 15 cpm
Life .... >500 Hours
Input Power .... 24-29 vdc
Output Power 2 amp. ind. @ 28 vdc
Power Consumption .... 7 watts max.
Qualified MIL-E-5272
Weight .... 3 lbs. max.

4 **DIPLEX FILTER DP—318**
Frequency .... 950 to 1215 mc
Filter Characteristics per Air Force Requirement - F-339/A MIL-F-25880
VSWR .... <1.4:1
R F Power .... 2 kw peak; 2 watts average
Weight .... 3.0 lbs.

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Program Excerpts of Interest to Microwave Engineers

1961 IRE INTERNATIONAL CONVENTION

March 20 through 23 has been selected as the date for the 1961 IRE International Convention, which will again be held at the Waldorf-Astoria Hotel and New York Coliseum in New York City. More than 70,000 engineers and scientists from 40 countries are expected to attend what has become the world's largest technical meeting and exhibition.

A comprehensive program of 275 papers, covering the most recent developments in the fields of all 28 IRE Professional Groups, will be presented in 54 sessions at the Waldorf-Astoria and the Coliseum. The high point of the program will be a special symposium on new energy sources to be held Tuesday evening, March 21, at the Waldorf.

The IRE Show, filling all four floors of the Coliseum, will accommodate approximately 850 exhibitors. Some $15,000,000 worth of the latest electronic equipment will be on display, most of it for the first time.

The social events will include a "get-together" cocktail party Monday evening and the annual IRE banquet Wednesday evening, both in the Grand Ballroom of the Waldorf. The banquet will feature the presentation of IRE Awards for 1961, including the Medal of Honor to Ernst A. Guillemin, Professor of Electrical Engineering at MIT, and the Founders Award to Ralph Bown, former Bell Laboratories scientist. An entertaining program of tours, fashion shows and matinees has also been arranged for wives of visitors.

Portions of the IRE program of special interest to microwave engineers are reprinted as follows:

MONDAY, MARCH 20, 1961

2:30 - 5:00 P.M.

SERT ROOM, WALDORF-ASTORIA

SESSION 4: **Radio Frequency Interference**

Chairman: **Dr. Joseph H. Vogelman**
Capehart Corp., Dynamic Electronics Div., 87-46 123 St., Richmond Hill 18, N. Y.

4.1 **Radiation Characteristics of Antenna at Other Than Design Frequencies**
J. C. Pullara and J. P. Jones, Melpar Inc., 3000 Arlington Blvd., Falls Church, Va.

4.2 **The Relationship Between Broadband Interference Measurements (DBMC) and Pulsed-CW Signals**
L. R. Pangburn, Light Military Electronics Dept., General Electric Co., Utica, N. Y.

4.3 **Shielding Enclosure Performance Utilizing New Techniques**
R. B. Schulz, Armour Research Foundation of Illinois Institute of Technology, 10 W. 35th St., Chicago, Illinois and D. P. Kanellakos, Radio Science Lab., Stanford Univ., Stanford, Cal.

4.4 **Graphical-Numerical Prediction of Tuned R-F Amplifier Output Spectrum**
W. G. Duff, Jansky & Bailey, Inc., 1339 Wisconsin Ave., N. W. Washington, D.C.

4.5 **Radar Mutual Interference Problem**
C. Gager, A. Ruvin, and C. Fowler, Airborne Instruments Lab., Deer Park, Long Island, N. Y.

Session Organizer: John F. Chappell
114 Forrest Ave.
Fair Haven, N. J.

2:30 - 5:00 P.M.

MARCONI HALL, NEW YORK COLISEUM

SESSION 7: **Advances in Navigation and Flight Safety Systems**

Chairman: **Ludlow B. Hallman, Jr.**
Wright Air Development Division
Wright-Patterson Air Force Base, Ohio

7.1 **Star Tracking and Scanning Systems — Their Performance and Parametric Design**
J. E. Abate, Astronautics Dept., Kearfott Div., General Precision, Inc., Little Falls, N. J.

7.2 **Semi-Automatic Flight Inspection of Navigation-Aid Stations**
J. S. Prichard, J. Lovell and E. Drogin, Airborne Instruments Lab., Deer Park, L. I., N. Y.

7.3 **An Active Radar Surveillance Beacon**
A. R. Almond and D. F. Gumb, Aero Geo Astro Corp., 1200 Duke St., Alexandria, Va.

7.4 **Gross Errors in Height Indications From Radar Altimeters Operating Over Thick Ice or Snow**
A. H. Waite and S. J. Schmidt, U. S. Army Signal R. & D. Lab., Ft. Monmouth, N. J.

7.5 **Performance in Clutter of Airborne Pulse MTI, CW Doppler, and Pulse Doppler Radar**
D. Mooney and G. Ralston, Air Arm Div., Westinghouse Electric Corp., Baltimore Md.

Session Organizer: Lester M. Glantz
Autometric Corporation, 1501 Broadway
New York 36, New York

TUESDAY, MARCH 21, 1961

10:00 A.M. - 12:30 P.M.

STARLIGHT ROOF, WALDORF-ASTORIA

SESSION 9: **Control Theory and Practice**

Chairman: **John E. Ward**
Assistant Director, Electronic Systems Laboratory, Massachusetts Institute of Technology, Cambridge 39, Massachusetts

9.1 **An Extension of Wiener Theory to Multivariable Controls**
L. G. McCracken, Dept. of Elec. Engrg., Lehigh Univ., Institute of Research, Bethlehem, Pa.

9.2 **Analysis of Linear Control Systems Containing Distributed and Lumped Parameters — A Comparative Study**
O. I. Elgerd, Dept. of Elec. Engrg., Univ. of Florida, Gainesville, Fla.

9.3 **Harmonic Analysis and Describing Function of Non-Linear Systems**
D. M. Makow, Radio and Elec. Engrg. Div., National Research Council, Ottowa 2, Ontario, Can.

9.4 **Considerations in the Optimum Design of a Precision Radar Track Loop**
Stephen Adelman, Surface Armament Div., Sperry Gyroscope Co., Great Neck, L. I., N. Y.

9.5 **Short Time Stability in Linear Time-Varying Systems**
Peter Dorato, Polytechnic Institute of Brooklyn, 333 Jay St., Brooklyn 1, N. Y.

Session Organizer: John M. Salzer
Ramo-Wooldridge
8433 Fallbrook Avenue, Canoga Park, California

10:00 A.M. - 12:30 P.M.

MARCONI HALL, NEW YORK COLISEUM

SESSION 15: **This World and The Adjacent One**

Chairman: **Dr. K. C. Black**
Institute of Defense Analysis
94 Massachusetts Avenue, Cambridge 39, Massachusetts

A. **Lunar Exploration**

15.1 **Velocity Sensing for Soft Lunar Landing by Correlation Between Spaced Microwave Receivers**
F. R. Dickey, Jr., Electronic Equipment and Systems Lab., GE Co., Syracuse, N. Y.

15.2 **Surveying and Mapping of the Moon from an Orbiter**
B. C. Aschenbrenner, Autometric

Corp., 1501 Broadway, New York 36, N. Y.

15.3 Summary of Methods and Results of Estimation of the Physical Constants of the Lunar Surface
K. M. Siegel, Radiation Lab., Dept. of Elec. Engrg., The Univ. of Michigan, Ann Arbor, Mich.

B. Meteorological Electronics Panel

15.4 The 433L Weather Data System
G. A. Guy, USAF, Air Force Command and Control Div., Bedford, Mass.

15.5 A K_a-Band Radar for Cloud Base and Top Measurements
Irwin Marson and Henry Katzenstein, Olympic Radio & Television Div., The Siegler Corp., 34-01 38th Ave., Long Island City 1, N. Y.

15.6 The AN/FMQ-5 Automatic Meteorological Station
J. Beck, Olympic Radio & Television Div., The Siegler Corp., 34-01 38th Ave., Long Island City 1, N. Y.

10:00 A.M. - 12:30 P.M.
MORSE HALL, NEW YORK COLISEUM
SESSION 16: Broadening Device Horizons
Chairman: John G. Linvill
Stanford University, Stanford, California

16.1 Electron Devices for Millimeter-Infrared Gap
P. D. Coleman, University of Illinois, Champaign, Ill.

16.2 Optical Masers
G. C. Dacey, Bell Tel. Labs., Murray Hill, N. J.

16.3 Solid State Devices
E. O. Johnson, RCA Semiconductor Div., Somerville, N. J.

Abstract

A panel of speakers on new developments in the field of electron devices which are continuing to broaden the vista of the electronics industry. The particularly significant frontier areas of Optical Masers and Devices for the Microwave-Infrared gap and the rapidly expanding field of Solid State Devices will be covered. These correlated talks will survey the current state of the art, consider application possibilities and indicate future development potentialities. Questions from the floor will be invited.

Session Organizer: R. W. Sears
Bell Telephone Laboratories, Inc.
Murray Hill, N. J.

2:30 - 5:00 P.M.
MORSE HALL, NEW YORK COLISEUM
SESSION 23: Microwave Devices
Chairman: Paul W. Crapuchettes
Litton Industries, 960 Industrial Way, San Carlos, California

23.1 A Tunable L-Bank Tunnel-Diode Amplifier
H. M. Wachowski, Kearfott Div., General Precision, Inc., 14844 Oxnard St., Van Nuys, Calif.

23.2 The Maser Amplifier as a Practical Microwave Component
F. E. Goodwin, J. E. Kiefer and G. E. Moss, Hughes Research Labs., 3011 Malibu Canyon Rd., Malibu, Calif.

23.3 A Voltage-Tunable Magnetron with a Matrix Cathode and Improved R-F Structure
J. W. McLaughlin, Eitel-McCullough Inc., 301 Industrial Way, San Carlos, Calif.

23.4 A New Method of Magnetron Tuning and Frequency Stabilization
R. M. Salzer and Reynold Steinhoff, Electron Tube Div., RCA, Harrison, N. J.

23.5 A Survey of the Elements of Power Transmission by Microwave Beam
W. C. Brown, Spencer Lab., Raytheon Co., Burlington, Mass.

Session Organizer: R. W. Sears
Bell Telephone Laboratories Murray Hill, New Jersey

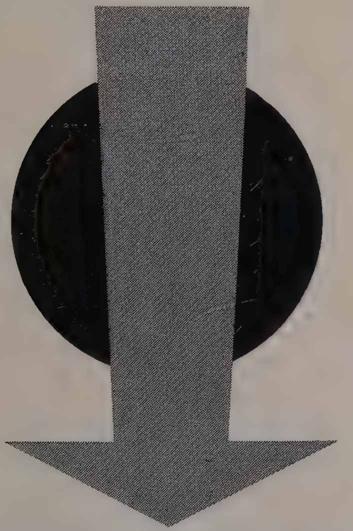
WEDNESDAY, MARCH 22, 1961

10:00 A.M. - 12:30 P.M.
STARLIGHT ROOF, WALDORF-ASTORIA
SESSION 25: Detection Theory and Signal Analysis
Chairman: George Turin
University of California, Berkeley 4, California

25.1 Applications of Stochastic Approximation Methods to Optimum Filter Design
D. J. Sakrison, MIT, Cambridge, Mass.

25.2 Radar System Performance in a Dense-Target Environment
E. N. Fowle, E. J. Kelly and J. A. Sheehan, Lincoln, Lab., MIT, P.O. Box 73, Lexington 73, Mass.

(*Continued on page 142*)



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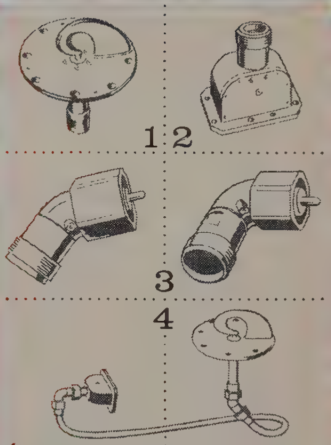

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IRE Program

(*Continued from page 141*)

25.3 A Method of Designing Signals of Large Time-Bandwidth Product
E. L. Key, Mitre Corp., Bedford, Mass., E. N. Fowle and R. D. Haggarty, Lincoln Lab., MIT, Lexington 73, Mass.

25.4 On the Recognition of Signal Patterns in Noise
J. K. Wolf, Communications Directorate, Rome Air Development Center, Griffiss AFB, N. Y., and J. B. Thomas, School of Engrg., Princeton Univ., Princeton, N. J.

Session Organizer: Benjamin F. Logan
Bell Tel. Labs., Room 2D-528, Murray Hill, New Jersey

10:00 A.M. - 12:30 P.M.

SERT ROOM, WALDORF-ASTORIA

SESSION 28: Space Electronics

Chairman: Philip D. Doersam,
Manager, Sub-System "F" Samos Program, Lockheed Missile and Space Division, Sunnyvale, California

28.1 The Effects of Van Allen Belt Radiation on Material
R. S. Shane, Light Military Electronics Dept., GE Co., Utica, N. Y.

28.2 The Existence of Periodic Variations in the Observations of Jovian Eclipses
Martin Ruderfer, Dimensions, Inc., 7314 20th Ave., Brooklyn 4, N. Y.

28.3 Atlas Missile Flight Safety for Project Mercury
J. W. Schaelchlin, R. D. Gadbois, and T. F. Heinsheimer, Convair (Astronautics) Div., General Dynamics Corp., P.O. Box 1128, San Diego 12, Calif.

28.4 Diagnostic Instrumentation for an Electric Propulsion Plasma Engine
L. Aronowitz and A. Steinberg, Plasma Propulsion Lab., Republic Aviation Corp., Farmingdale, N. Y.

28.5 Inherent Errors in Locating Electrical Storms with a Surveillance Satellite
R. A. Whiteman and D. Fryberger, Armour Research Foundation Technology Center, 10 W. 35 St., Chicago 16, Ill.

28.6 Logarithmic Navigation for Precise Guidance of Space Vehicles
W. G. Green, Astrionics Lab., ITT Labs., 3700 East Pontiac St., Ft. Wayne, Ind.

Session Organizer: C. H. Doersam
Potter Instrument Company, Inc., Sunnyside Blvd., Plainview, L. I., N. Y.

10:00 A.M. - 12:30 P.M.

MORSE HALL, NEW YORK COLISEUM

SESSION 32: Microwave Solid State

Chairman: Harold Seidel
Bell Telephone Laboratories
Murray Hill, N. J.

32.1 Recent Advances in Solid State Microwave Devices
M. E. Hines, A. Uhlir and R. Damon, Microwave Associates, Inc., Burlington, Mass.

32.2 Microwave Ferrite Stripline Filter and Power Limiter
John Carter, Irving Reingold, USA Sig. R&D Labs., Ft. Monmouth, N. J. and R. A. Moore, Air Arm Div., Westinghouse Electric Corp., Baltimore 3, Md.

32.3 Ferrite Post Microwave Resonant Structure
W. J. Parris and R. A. Moore, Air Arm Div., Westinghouse Electric Corp., Baltimore 3, Md.

32.4 X-Band Parametric Amplification — An Integrated Approach to the Diode and Circuit Problem
S. M. Ku, R. I. Harrison and S. W Harrison, General Telephone & Electronics Labs., Inc., Bayside, L. I., N. Y.

32.5 Recent Advances in Microwave Mixers
Robert Tenenholtz, Sage Labs., Inc., Natick, Mass.

Session Organizer: Tore N. Anderson
1539 Deer Path,
Mountainside, N. J.

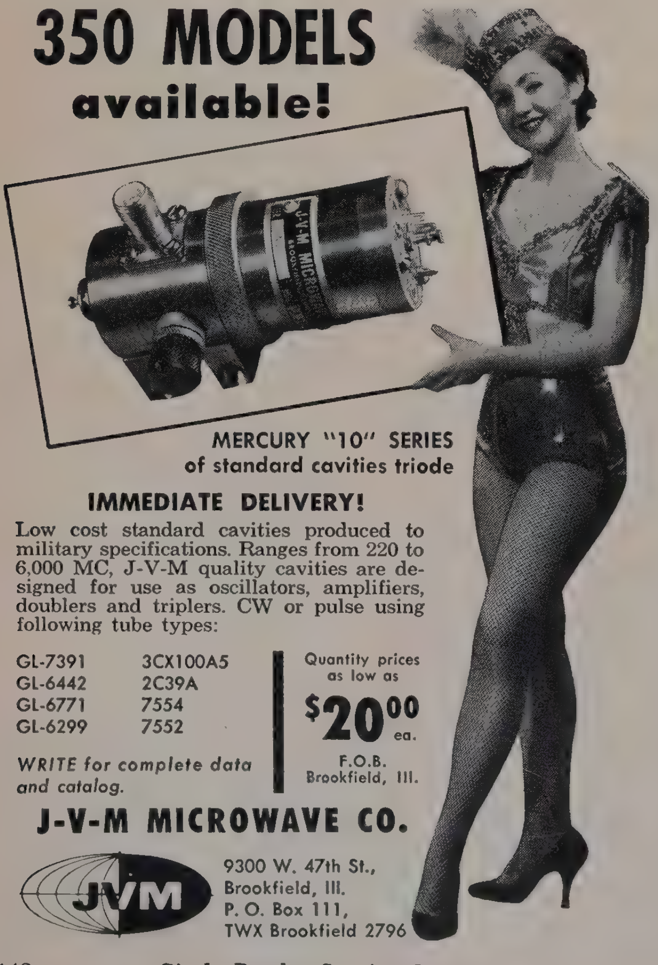
2:30 - 5:00 P.M.

SERT ROOM, WALDORF-ASTORIA

SESSION 36: Telemetry

Chairman: Robert V. Werner
Executive Vice President, Cubic Corporation, San Diego, California

36.1 The Use of Magnetic Fields in Elimination of Re-entry Radio Blackout



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Sept., 1960 — 288 pages — 6 x 9" illus. — $12

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H. Hodara, The Hallicrafters Co., 5th & Kostner Aves., Chicago 24, Ill.

36.2 Data Transmission for the NRL Space Surveillance System
M. G. Kaufman and F. X. Downey, U. S. Naval Research Lab., Washington 25, D.C.

36.3 A Predetection Recording Telemetry System
W. R. Johnson and G. N. Johnson, Mincom Div., Minnesota Mining and Mfg. Co., 2049 So. Barrington Ave., Los Angeles 25, Calif.

36.4 PCM Telemetry Recording at High Densities
G. E. Comstock, III, Potter Instrument Co., Inc., Sunnyside Blvd., Plainview, N. Y.

36.5 Globetrotter — An Air Transportable Satellite Tracking Station
R. L. Scrafford, Space Technology Labs., Inc., P.O. Box 95001, Los Angeles 45, Calif.

36.6 The Courier Recorder-Reproducers
J. P. Buffington and S. L. Wiig, Advanced Electronic Data Labs., Div. Consolidated Electrodynamics Corp., 620 No. Lake Ave., Pasadena, Calif.

Session Organizer: C. H. Doersam
Potter Instrument Co.
Inc., Sunnyside Blvd.,
Plainview, L. I.,
N. Y.

2:30 - 5:00 P.M.

MARCONI HALL, NEW YORK COLISEUM

SESSION 38: Propagation

Chairman: Dr. Sidney A. Bowhill
222 Electrical Engineering, Pennsylvania State University, University Park, Pa.

38.1 The Plasmas of Rocket Flight
W. W. Balwanz, Naval Research Labs., Washington, D.C.

38.2 Enhancement of Radar Returns Through Double Bounce Circular Polarization
Sheldon Isaacson, The Martin Co., Orlando, Fla.

38.3 VHF and UHF Signal Characteristics Observed on a Long Knife-Edge Diffraction Path
A. P. Barsis and R. S. Kirby, National Bureau of Standards, Boulder, Colo.

38.4 An Ionospheric Scatter Mode Associated with the Earth's Magnetic Field
Byron Bailin, Rome Air Development Center, Griffiss AFB, N. Y., and J. L. Heritage, Smyth Research Associates, 3555 Aero Court, San Diego, Calif.

38.5 Wave Propagation in Magneto-Ionic Media
H. Hodara, The Hallicrafters Co., 5th & Kostner Aves., Chicago 24, Ill.

Session Organizer: Harry Fine
1233 Valley Ave.,
S. E. Washington,
D.C.

2:30 - 5:00 P.M.

MORSE HALL, NEW YORK COLISEUM

SESSION 39: Microwave Measurements

Chairman: Dr. Helmut M. Altschuler
Microwave Research Institute
55 Johnson Street, Brooklyn 1, New York

39.1 A Precision Microwave Phase-Measurement System with Sweep Presentation
S. B. Cohn and H. G. Oltman, Rantec Corp., 23999 Ventura Blvd., Calabasas, Calif.

39.2 A Precise Method for Measuring the Incremental Phase and Gain Variations of a Traveling Wave Tube
A. Zacharias, Bell Tel. Labs., Murray Hill, N. J.

39.3 A Transient Analysis of the Traveling-Wave Resonator with Application to High-Power Microwave Testing
Henry Berger, Sperry Gyroscope Co., Great Neck, N. Y.

39.4 Gas Discharge Noise Sources in Pulsed Operation
N. J. Kuhn and M. R. Negrete, Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif.

39.5 A Sequential Detection System for the Processing of Radar Returns
A. A. Galvin, Lincoln Lab., MIT, Lexington 73, Mass.

Session Organizer: Tore N. Anderson
1539 Deer Path,
Mountainside, N. J.

THURSDAY, MARCH 23, 1961

10:00 A.M. - 12:30 P.M.

SERT ROOM, WALDORF-ASTORIA
SESSION 43: Radar

Chairman: Salvatore E. Petrillo,
Director of Engineering, U.S. Army Signal Research and Development Laboratory, Fort Monmouth, New Jersey

43.1 The Exploration of a Given Volume with a High Accuracy Radar: Considerations of Power, Data Rate and Accuracy
P. R. Dax, Westinghouse Electric Corp., P.O. Box 1897, Baltimore, Md.

43.2 Correlation Radar Using Pseudo-Random Modulation
W. Fishbein, and O. E. Rittenbach, Radar Division, U. S. Army Signal Research and Development Lab., Ft. Monmouth, N. J.

43.3 Single Pulse AFC System
J. G. Isabeau, Chief, Special Products Section, R S Electronic Corp., P.O. Box 368, Station A, Palo Alto, Calif.

43.4 An Experimental Laser Radar
D. A. Buddenhagen, B. A. Lengyel, F. J. McClung, Jr., and G. F. Smith, Hughes Research Labs., Malibu, Calif.

43.5 Application of Molded Wiring Boards to Low Quantity Production
J. C. Gioia, Light Military Electronics Dept., GE Co., Utica, N. Y.

Session Organizer: Craig M. Crenshaw
5003 Waggaman Circle, McLean, Virginia

(*Continued on page 144*)

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STREPITUM MINUERE

"To Restrain Noise"... One of the tasks at ATI is that of developing low-noise broad-band preamplifiers per specific operational requirements. In reconnaissance and surveillance activities low-noise preamplifiers with octave, or greater, bandwidths are needed to augment ELINT (ELectronic INTelligence) Collection Systems. In supplying equipments meeting these requirements, ATI has produced a line of low-noise preamplifiers that span the VHF through the microwave frequency domain. Typical VHF preamplifiers have bandwidths exceeding three octaves with noise figures less than 6 db.

Another recent task involved the development of a miniature 160 Mc amplifier having a noise figure less than 3.5 db. This item is now in production.

Other development efforts involving classified techniques and devices are directed toward achieving greater bandwidths with lower noise figures while maintaining the objective of practical end item equipment to satisfy an operational requirement.

Interested engineers who desire to become part of a task-oriented organization where the individual participates "from concept to reality" are invited to submit their experience resumes to Dr. John L. Grigsby, Chief Engineer.

ATI

AREAS OF SPECIALIZATION:
- ELINT Receiving Systems
- Deceptive Electronic Countermeasures
- Broad-Band Amplification
- Ionosphere Research Instrumentation
- Radio Astronomy Instrumentation
- Microwave Radiometry

APPLIED TECHNOLOGY, INC.
930 Industrial Avenue • Palo Alto, California

Circle Reader Service Card 93

IRE Program

(*Continued from page 143*)

10:00 A.M. - 12:30 P.M.
EMPIRE ROOM, WALDORF-ASTORIA
SESSION 44: Space Communication Systems of the Future

Chairman: Prof. Walter Lyons
RCA Communications, Inc., 66 Broad Street, New York 4, New York

44.1 Decision Feedback Under Adverse Noise Conditions
H. A. Lindgren, Stanford Research Institute, Menlo Park, Calif.

44.2 A Solid State Crystal Controlled FM Transmitter for 150 M/c Band
R. H. Taplin, IT&T Labs., 500 Washington Ave., Nutley 10, N. J.

44.3 Pseudoredundancy in Communication Systems
R. N. Close, M. Schwartz, M. Chomet, H. Keen, L. Fogel, Airborne Instruments Lab., Deer Park, L. I., N. Y.

44.4 The Courier Communications Satellite Electrical Design
J. M. Rosenberg, J. T. Nawrocki, H. A. Kelley, Philco Corp., Western Development Labs., 3875 Fabian Way, Palo Alto, Calif.

44.5 The Dwindling High Frequency Spectrum
George Jacobs and E. T. Martin, Broadcasting Service, U. S. Information Agency, Washington 25, D.C.

44.6 The First Commercial Comprehensive Microwave and Tropospheric Communication System in South America
F. B. Woodworth, Oficina Tecnica Amando Capriles CA Box 3372, Caracas, Venezuela

Session Organizer: Leonard R. Kahn
Kahn Research Labs., 22 Pine St., Freeport, L. I., N. Y.

10:00 A.M. - 12:30 P.M.
FARADAY HALL, NEW YORK COLISEUM
SESSION 45: Human Factors in Electronics

Chairman: Alexander E. Javitz
Electro Technology, 205 East 42nd St., New York 17, N. Y.

45.1 Radar Target Identification by Aural Display
R. W. Pew, Psychology Dept., Univ. of Michigan, Ann Arbor, Mich., and J. I. Elkind, Bolt, Beranek & Newman, 50 Moulton St., Cambridge 38, Mass.

45.2 Acoustic Iso-Preference Contours and TPU's
W. A. Munson and J. E. Karlin, Bell Tel. Labs., Murray Hill, N. J.

45.3 A Judgmental Method for Voice Communication System Evaluation
W. R. Roberts, ITT Labs., Palo Alto, Calif.

45.4 The Application of Feedback Techniques to the Measurement of Maximum Human Operator Bandwidth in Closed Loop Control
J. S. Sweeney and H. P. Birmingham, U. S. Naval Research Lab., Washington 25, D.C.

45.5 Why Design for Maintainability?
J. G. Wohl, Dunlap and Associates, 429 Atlantic St., Stamford, Conn.

Session Organizer: Robert R. Riesz
Bell Tel Labs., Murray Hill, New Jersey

10:00 A.M. - 12:30 P.M.
MARCONI HALL, NEW YORK COLISEUM
SESSION 46: Antennas

Chairman: Dr. Robert J. Adams
Naval Research Laboratory, Washington, D.C.

46.1 A Monopulse Antenna Having Independent Optimization of the Sum and Difference Modes
P. W. Hannan and P. A. Loth, Wheeler Labs., Smithtown, N. Y.

46.2 Calculation of Radiation Patterns from Apertures with Arbitrary Field Distributions by the Fourier Integral Method
J. S. Hollis and R. E. Moseley, Scientific-Atlanta, Inc., 2162 Piedmont Rd., N.E., Atlanta 9, Ga.

46.3 The Design of Log-Periodic Dipole Antennas
R. L. Carrel, Univ. of Illinois, Urbana, Ill.

46.4 Log-Periodic Monopole Array
D. G. Berry and F. R. Ore, Research Div., Collins Radio Co., Cedar Rapids, Iowa

46.5 Helical Top-Loading of Electrically Small Monopole Antennas
R. O. Schildknecht, ITT Labs., 500 Washington Ave., Nutley, N. J.

Session Organizer Harry Fine, 1233 Valley Ave., S.E. Washington, D.C.

2:30 - 5:00 P.M.
MARCONI HALL, NEW YORK COLISEUM
SESSION 53: Antennas

Chairman: Delmar C. Ports
Jansky & Bailey, 1339 Wisconsin Ave., N.W. Washington, D.C.

53.1 Optimizing the Performance of Very High Gain Low Noise Antenna Systems
R. Caldecott, J. W. Eberle, T. G. Hame, Dept. of Elec. Engrg., Ohio State Univ., Columbus, Ohio

53.2 Far Field Properties of Wide Band Planar Arrays with Nonlinear Processing
E. D. Banta, General Atronics Corp., 1 Bala Ave., Bala-Cynwyd, Pa.

53.3 Frequency Scanning Antennas
Akira Ishimaru and Hang-Sheng Tuan, Dept. of Elec. Engrg., Univ of Washington, Seattle, Wash.

53.4 A Critical Study of Linear Arrays with Equal Side Lobes
M. T. Ma and D. K. Cheng, Dept. of Elec. Engrg., Syracuse Univ., Syracuse, N. Y.

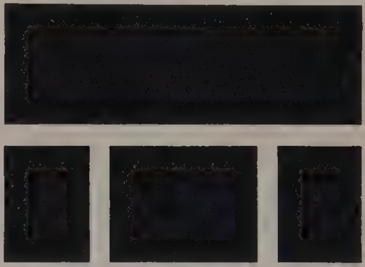
53.5 Maintaining Fixed Phase Differences Between Microwave Signals Generated at Remote Sites
S. B. Boor and R. J. Wohlers, Research Div., Radiation, Inc., P.O. Box 6904, Orlando, Fla.

Session Organizer: Harry Fine, 1233 Valley Ave., S.E. Washington, D.C.

—*mwj*—

A Complete Ferrite Operation

with new expanded grinding service



Now in one plant. *Here's why!*

With new enlarged facilities we can offer you these immediate advantages:

Savings On Valuable Transfer Time and Expense—Our research, testing, production and new grinding service are under one roof. Therefore, the time and expense—often lost in shipping from manufacture to customer, then to grinding facility and finally back to customer—is saved. Instead, we produce ferrites and grind them, too. All in continuous operation and at one central plant. Multiple handling is eliminated.

Elimination Of Your Risk On Breakage—We accept responsibility for all breakage because the job never leaves our plant. Danger of ferrite breakage on-route from manufacture to grinder, and then on to you, is eliminated.

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Our new plant has the most modern grinding machinery; operated by men who know and understand ferrite. We prepare ferrite for finished use in both round and flat configurations of every design. Your inquiry into our expanded grinding service is invited.

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foremost in ferrites

New Location: P. O. B. #457, Gaithersburg, Md.

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P. J. Engineering Sales Co., Watertown, Mass.

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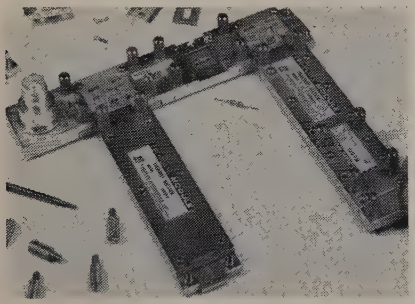
Booth Information

SANDERS ASSOCIATES, INC.
BOOTH 1723



New tri-Plate® semiconductor mount kits for breadboarding advanced varactor, tunnel diode and transistor circuits will be displayed by Sanders Associates, Inc., Nashua, N. H. at the IRE Show.

The kits make it possible to assemble harmonic generators, parametric amplifiers, oscillators, pulse amplifiers and down converters in minutes.

Eleven of the most commonly used semiconductor device packages are accommodated by the new Tri-Plate kits. Such configurations as series or shunt connected, double-ended cartridges, pigtail devices, TO-18 and TO-5 packages, ceramic cartridges, and several types of pill packages are merely placed in the respective Tri-Plate semiconductor mounts included in the kit.

Complete circuit subassemblies using one, two, three, or four port mounts with RF bypass, ground return and/or bias provision are assembled in minutes. Substantial cuts in breadboarding time and module versatility are important features with Tri-Plate modules. Such things as subnanosecond switching speeds or CW operation, up to seven kMc are possible with Sanders' new semiconductor mount kits.

Circle Reader Service Card 137

—*mwj*—

SIERRA ELECTRONIC CORP.
BOOTHS 3031-32

An RF calibration test set, a new plug-in element for bi-directional power monitors and a transistor tester are among the new electronic equipment to be introduced by Sierra Electronic Corp., Menlo Park, Cal., at the IRE Show.

Model 1223 RF Calibration test set provides an accurate, stable source of RF power for the calibration of RF power measuring equipment. The output power is variable in six fixed steps from 5 through 125 watts.

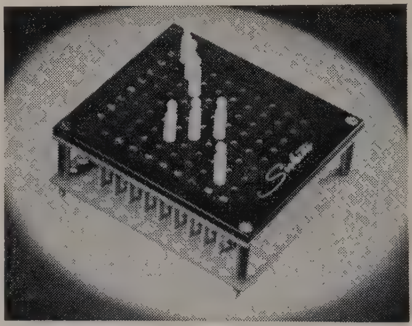
Model 270A-470 plug-in element is newly-designed for the Sierra bi-directional power monitors (164 Series). The monitors are compact, versatile instruments for intermittent or continuous measuring of incident and reflected power, or precise matching of loads to lines. Power is read directly on a linear scale with an accuracy of ± five per cent.

Model 219B transistor tester is a newly-designed instrument which provides convenient measurement of the transistor Beta parameter while the transistor remains in the circuit.

Circle Reader Service Card 138

—*mwj*—

SEALECTRO CORP.
BOOTH 2919



Among the new products shown by the Sealectro Corporation, Mamaroneck, N. Y. will be a greatly extended line of "Press-Fit" Teflon terminals, a new concept in "ConheX" sub-miniature rf connectors, and a complete cordless program system utilizing the Sealectoboard.

The "Press-Fit" Teflon terminal line will show a still greater selection of body and stud configurations. Currently, this Sealectro product line contains over 4000 standard numbers. Sealectro also maintains a complete engineering and design department to meet beyond-the-usual needs with appropriate designs.

Sealectro's "ConheX" sub-miniature rf connector line is now available in two basic designs.

Circle Reader Service Card 139

—*mwj*—

DOW CORNING CORP.
BOOTHS 4310-12

A new silicone encapsulating material that permits visual inspection of circuits and components within potted, embedded or encapsulated assemblies will be introduced at the IRE Convention by Dow Corning Corp., Midland, Mich.

The new encapsulant will be designated as Sylgard 182 Resin.

Applied as an almost colorless liquid—after blending with its curing agent — Sylgard 182 cures in place even in totally confined enclosures, to form a transparent mass having outstanding dielectric properties, good moisture resistance and the physical attributes of flexibility and toughness.

Curing time for Sylgard 182 Resin can be varied by changing the curing temperature. At 150°C, it cures in 15 minutes; at 65°C, four hours; at 25°C, three days. Neither the resin nor its curing agent is toxic to the skin. No toxic fumes are given off during mixing or curing.

Circle Reader Service Card 140

—*mwj*—

JERROLD ELECTRONICS CORP.
BOOTHS 3904-06

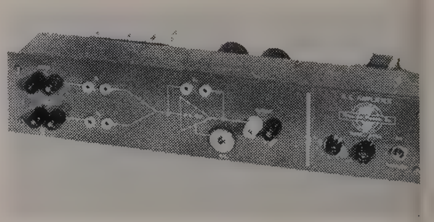
A new RF Sweep Signal Generator (Jerrold Model 900-B) which offers a combination of measurement functions and eliminates the need for much of the test equipment now required for RF sweep frequency measurements between 500 kc and 1200 Mc is announced by Jerrold Electronics Corp., Philadelphia, Pa.

Sweep widths as narrow as 10 kc and as broad as 400 Mc; high stability; built-in attenuator, marker generator, and scope preamplifier; accurately, calibrated center frequency dial; metered output are among the features of the 900 B, which will be shown at the IRE Show.

Circle Reader Service Card 141

—*mwj*—

MICRO GEE PRODUCTS, INC.



Micro Gee Products, Inc., Culver City, Cal., announces a new low cost dc Operational Amplifier designed for rack mounting in a standard 19 inch wide rack.

The Model 505A consumes only 3½ inches of vertical rack space, is completely self-contained, operating directly from a 115 volt 60 cps line, and features response to five kc and an open loop gain of 5000. A chopper stabilized version, the Model 505AS is also available, offering dc gain in excess of 10^6.

The eight milliampere bipolar output urrent capability allows use with servo-alves, recorders, galvanometers and simiar instrumentation. Dual inputs are proided for use in command-feedback servo oops. A novel feature is a front panel resentation of the operational block diaram with standard binding posts for inut, feedback and output functions apropriately located on this diagram.

Circle Reader Service Card 142

—*mwj*—

SYLVANIA ELECTRIC PRODUCTS INC.

BOOTHS 2322-32 AND 2415-25

A five inch industrial "Bonded Shield" athode ray tube which features a permaent built-in reference scale on an integral eflection-free safety panel, will be demonstrated by Sylvania Electric Products nc., N. Y., N. Y. at the IRE Show.

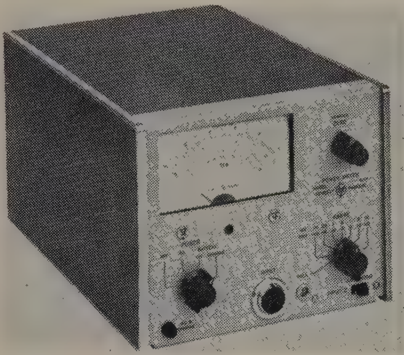
Designated Type SC-3076, the new Sylania tube offers maximum image visibility, wide angle viewing, simplified mounting styling, decreased reflection, protection against breakage, simplified tube face cleaning, and a self-contained writing surface.

Circle Reader Service Card 143

—*mwj*—

HEWLETT-PACKARD CO.

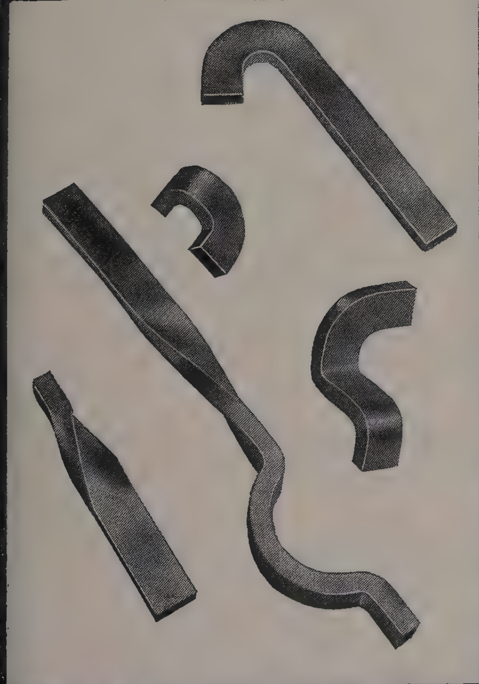
BOOTHS 3205-15



Thirty-three new instruments for making time-saving electronic measurements will be introduced by Hewlett-Packard Co., Palo Alto, Cal., at the 1961 IRE Show.

Hewlett-Packard's 60-foot booth will be divided into major areas of electronic measurement and will include new frequency standards, counters, audio/video

(*Continued on page 148*)



WAVEGUIDE

SPECIALISTS IN CLOSE TOLERANCE BENDING AND FORMING

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135 ORANGE ST., BLOOMFIELD, N. J.

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MAX-IMUM

MINIATURIZATION

ACF ELECTRONICS MICROWAVE EQUIPMENT

System-tested in operational space vehicles. Engineered to meet complete military missile specifications.

BAND PASS FILTER PANELS

MODEL NO. 325A Series

Frequency Range: 250 MC through 20.0 KMC

Tuning Range: Minimum 10% of operating frequency*

Bandwidth: 8 MC min. ± 15% variation over tuning range**

Insertion Loss: Commensurate with bandwidth requirements

Tuning: Single knob

*Available with calibrated dial

**Bandwidth and selectivity can be modified to meet customers' requirements

Standard designs modified to meet specific requirements. Complete manufacturing and engineering facilities supported by expert field service.

There's an ACF Electronics microwave component to meet requirements in L, S, C or X-Band Frequencies.

ACF RADAR BEACONS are in a majority of orbited satellites and major missile programs.

For information or prices write or call:

ACF ELECTRONICS

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Booth No. 1226—At New York IRE Show

March 20-23

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MICROWAVE MECHANICAL
GOMBOS
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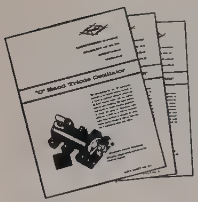
WRITE TODAY for literature on the John Gombos Co., Inc. line of Triode Oscillators and Amplifiers, Tunable Band Pass Filters and Front End Assemblies. We would also appreciate receiving your special requirements for active and passive Cavities, Components and Sub-systems.



JOHN
GOMBOS
CO., INC.

WEBRO ROAD, CLIFTON, N. J.

See us at the IRE Show—
Booths 2818 and 2820.

Circle Reader Service Card 98

IRE Booths

(*Continued from page 147*)

devices, oscilloscopes and microwave measuring equipment.

A special section of the booth will be devoted to the company's cabinet configuration program. This program has resulted in the design of an entirely new type of cabinet configuration for Hewlett-Packard instruments. The configuration is based on a modular design wherein standard bench models can be easily converted to rack-mounted instruments with the addition of brackets provided with the instrument.

Circle Reader Service Card 144

—*mwj*—

RAYTHEON COMPANY

A new voltage tunable, backward wave oscillator, designed for applications where frequency stability is essential, will be introduced by the Microwave and Power Tube Division of Raytheon Co., Waltham, Mass. at the IRE Show.

In addition, Raytheon's S-band QKB924 may be used as a driver tube with amplifier chains also being introduced by Raytheon at the show. The amplifier chain on display will include this new bwo, the QKS622 Amplitron, QKW750A traveling wave tube, power supplies and ferrite devices.

The QKB924 employs a compact permanent magnet for beam focusing and has control electrode for low voltage pulse or amplitude modulation. It has provision for external feedback which result in essentially flat frequency versus voltage characteristics at discrete steps.

Frequency range is from 2700 to 320 Mc. Typical power output is 100 mw wit delay line tuning voltage of 350 to 70 volts.

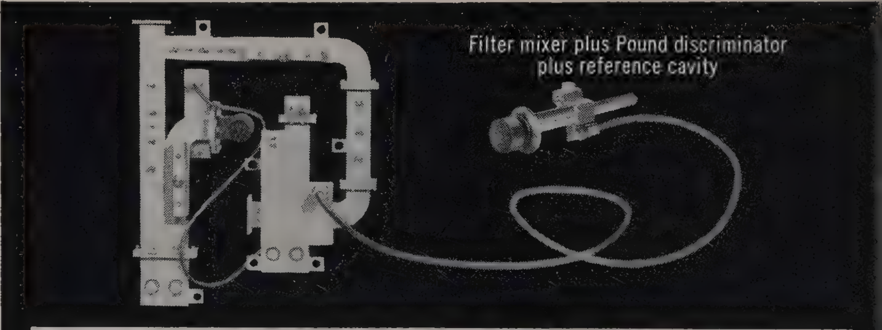
Circle Reader Service Card 145

—*mwj*—

FREQUENCY STANDARDS BOOTH 3844

A new high power band-pass filter, capable of handling a peak transmitted powe of three to five Mw with an average power of 15 kw and insertion loss of 0.15 db max. is announced by Frequency Standards, Asbury Park, N. J.

Through the utilization of coaxial transmission line, the filter achieves efficient power handling capacity in the smallest package possible. This unit has been



PORTCHESTER
THE SPECIALIST IN THE FIELD
FOR LINK SYSTEMS WAVEGUIDES

Portchester is a company devoted exclusively to the design and manufacture of waveguide link components. Through specialization, Portchester has developed advanced engineering abilities and economical, streamlined production facilities capable of producing complete assemblies under our own rigid testing and quality control. See us for:

Tees • Loads • Converters • Hybrids • Couplers • Tuning Units Waveguide Filters • Attenuators • Bends & Twists • Waveguide Discriminators • Antenna Feed Horns • Crystal Mounts • Klystron Mounts • Waveguide Cavities • Wavemeters

PORTCHESTER INSTRUMENT CORPORATION
Wholly-Owned Subsidiary of Premier Microwave Corp.
114 Wilkins Avenue, Port Chester, N.Y.

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ompletely tested at rated power and may e operated without external cooling. It s suited for high power radar transmitters nd space communications systems.

The present model has a frequency of 00 Mc but future developments will exend the range from 200 Mc to 1200 Mc. andwidth is eight per cent to the three lb points with rejection 50 db or greater t 1.15 F_0 and 0.85 F_0.

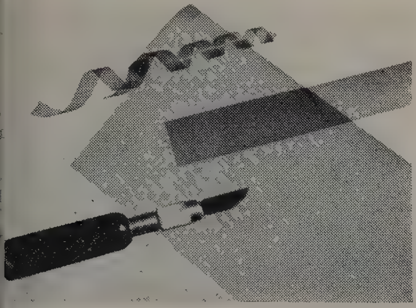
The filter is equipped with a 3 1/8 inch oaxial connector.

Circle Reader Service Card 146

—*mwj*—

FILMOHM CORP.
BOOTH 1806

On display at the IRE Show will be new, highly stable, ultra-thin metal film nylar from Filmohm Corp., ~~N. Y.~~, N. Y.



The metal film mylar is a completely lexible microwave absorbing material. The resistance material is a thin film of pure metals, approximately 50 millionths of an inch thick, uniformly deposited on the surface of the mylar.

The absorber is well-suited for those applications which require a thin film applied to a circular or eccentric contour. It can be used to line the inside of a cavity as a mode suppressor, or to wrap around the shorting plunger in a cavity to reduce and suppress leakage. It can be cut to shape and selectively bonded to antennas to absorb spurious energy.

It is easily fabricated, and easily laminated to all plastics or metals. In applications where the resistance film may tend to be scratched the material can be sandwiched by using two sheets of mylar, laminated together with the resistance film between, to form a completely protected and balanced dielectric assembly. Using .001 mylar, sandwiched assemblies .0025 inch to .0030 inch thickness can be made; .002 Filmohm mylar when sandwiched is .005 inch in total thickness.

Circle Reader Service Card 147

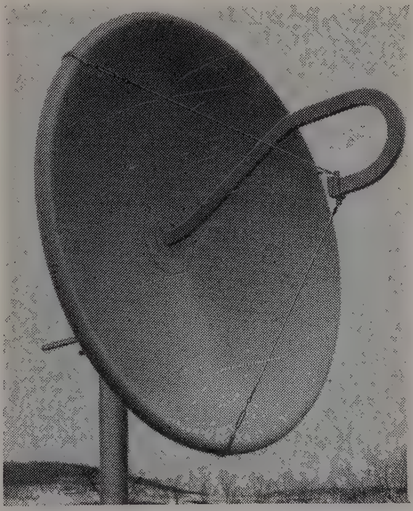
—*mwj*—

TACO
BOOTH 1207

Technical Appliance Corporation, Sherburne, N. Y., designers and manufacturers of antennas, antenna systems and allied accessories for both the industrial and defense markets will show two new product lines for the first time at the IRE Convention in New York.

TACO will introduce these new products: microwave antennas and rigid coaxial transmission line. Complete catalogs, meeting all popular useages in both the industrial and military areas, will be made available at the show.

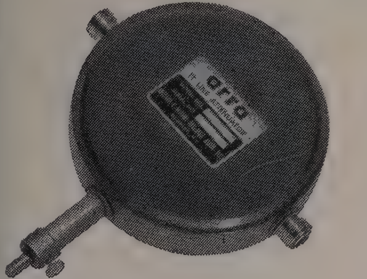
The new TACO Microwave Antenna line includes frequency ranges from 806 Mc to 12.7 kMc. Reflector sizes range from two to 12 feet, depending on frequency range. A highlight of the line is 12-foot mesh reflector available in the 900 Mc and 2000 Mc frequency bands. In addition, the new Taco line offers a choice of either spun or mesh reflectors in four, six,



(*Continued on page 151*)

arra π LINE CONTINUOUSLY

VARIABLE ATTENUATOR



Exclusive Features:

- Broadband Impedance Match.
- Min. VSWR for all values of attenuation over band.
- Insertion Loss: 0.2 db max.
- Drive: Shaft drives for systems & power level applications.
- Connectors: Type "N" Female (others on request).
- Size: 5" dia. x 1" high, excluding connectors and micrometer.
- Power Rating: 10 watts average min.
- Continuously variable for all values of attenuation.

Write for Information — Dept. P-IRE

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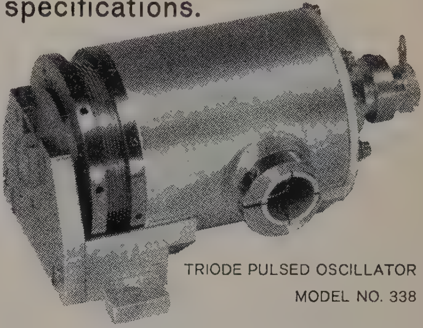
MAX-IMUM
MINIATURIZATION

ACF ELECTRONICS C-BAND MICROWAVE COMPONENTS

System-tested in operational space vehicles. Engineered to meet complete military missile specifications.



TRIODE PULSED OSCILLATOR
MODEL NO. 338

Specifically designed for transmitter service in missile and drone type Radar Beacons.

Frequency Range: 5400 to 5900 MC

Power Output: 1000 watts; peak

Stability: ± 3 MC over all military environmental conditions

Pulling Factor: Less than ± 2.5 MC for 1.5 VSWR, all phases

Pushing Factor: Less than 5 MC/amp of anode current

Load Variation: Can withstand VSWR's of 6:1 at any arbitrary phase without impairing life expectancy

Complete manufacturing and engineering facilities supported by expert field service.

There's an ACF Electronics microwave component to meet requirements in L, S, C or X-Band Frequencies.

ACF RADAR BEACONS are in a majority of orbited satellites and major missile programs.

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March 20-23

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COMPACT, RELIABLE, RUGGED EG&G CERAMIC-METAL

HYDROGEN THYRATRONS — HYDROGEN DIODES — TRIGGERED SPARK GAPS

THYRATRONS

These miniaturized hydrogen thyratrons were developed for compact modulator design for missile, airborne, and ground-based applications where size and weight are major considerations. Ruggedly built, they will withstand severe shock, vibration and high temperatures. Write for Data Sheet #040.

7621/HY-2
Functionally replaces 1258, 3C45 and most 4C35 glass tubes

7620/HY-1
Functionally replaces 4C35, 5C22 and most 5949 glass tubes

7322/1802
Functionally replaces 5949, 5948 and most 1257 glass tubes

THYRATRON RATING CHART

MODEL	epy v.	ib a	Ib mAdc	Ip Aac	Ef Vac ±7.5%	If Aac—max. Ef=6.3v	Eres Vac ±7.5%	Ires Aac—max. Eres=6.3v	Pb	Cathode & Reservoir Warm-Up Time	Dimensions Max. Height-inches	Dimensions Max. Dia.-inches	Wt. lbs.
7621/HY-2	8,000	100	0.1	2.0	6.3	3.5	*	*	2.7 x 10^9	0.5 min.	2½″	1⅕″	0.13
7620/HY-1	20,000	500	0.5	8.0	6.3	7.5	6.3	4	10 x 10^9	5 min.	4⅝″	2 5/16″	0.82
7322/1802	25,000	1,500	1.5	47.5	6.3	16	6.3	6	20 x 10^9	10 min.	5¾″	3⅜″	2.07

*Hydrogen reservoir connected internally across heater-cathode.
Ambient Temperature Limits —65°C to +125°C, 400°C envelope maximum.

DIODES

HR-2

HR-1

HR-3

High power, high voltage, hydrogen filled diodes designed for use as grid controlled rectifiers, hold-off diodes, inverse clippers and backswing clippers. In spite of their small size and light weight, they are of rugged construction and will withstand severe shock, vibration and high temperatures. Write for Data Sheet #050.

DIODE RATING CHART

	Clipper Diode Ratings				Rectifier Ratings			Heater				Cathode & Reservoir Warm-up Time	Dimensions		Wt.
Type	epx kv	ib a	Ib Adc	Ip Aac	epx kv	ib a	Ib Adc	Ef Vac	If Iac max.	Eres Vac	Ires Iac max.	minutes	Max. Height-inches	Max. Dia.-inches	lbs.
HR-2	8.0	9.0	.100	2.0	8.0	1.5	0.25	6.3	3.2	*	*	0.5	2½	1⅕	0.13
HR-1	25.0	250	.125	4.0	20.0	9.0	1.5	5.0	9.5	5.0	3.5	5	4⅝	2 5/16	0.95
HR-3	25.0	500	.500	16.0	25.0	30.0	5.0	6.3	13.0	6.3	4.0	10	5¾	3⅜	2.07

*Hydrogen reservoir connected internally across cathode-heater.
Ambient Temperature Limits —65°C to +125°C ambient, 400°C envelope maximum.

TRIGGERED SPARK GAPS

CERAMIC-METAL MODEL GP-12
Voltage holdoff — 25kv.
Peak current — in excess of 10,000 amperes
Trigger voltage — 7 kv. min.
Electrode to electrode cut-off voltage — 6 kv. min.
Delay time — 0.5 microseconds.
Size: 3½″ dia. x 2½″. Wt. .73 lb.

These compact spark gaps are designed to replace hydrogen thyratrons in electronic crowbar applications. They have a low trigger energy requirement and a fast follow-through time after application of trigger pulse. Hermetically sealed, they are not affected by atmospheric conditions. Ruggedly built to withstand severe shock, vibration and high temperatures. No filament power required. Complete specifications available on request. Write for Data Sheet #080.

GLASS-METAL MODEL GP-11
Voltage holdoff — 3.5 kv.
Peak current — in excess of 1100 amperes.
Trigger voltage — 7.5 kv. min.
Electrode to electrode cut-off voltage — 1.8 kv. min.
Delay time — 0.35 microseconds.
Size: 0.6″ dia. x 0.55″. Wt. .016 lb.

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7-9633, CUmberland 3-6555; **SAN CARLOS, Calif.,** 1682 Laurel Street, LYtell 3-7693; **SAN DIEGO, Calif.,** 1864 Bacon Street, ACademy 3-7138.

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TRAK Type 9127-SL(CW), tunable 2.15—2.45 KMc

NEW—TRAK OSCILLATOR CAVITY FOR CW SERVICE!

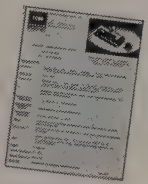
This MINIATURE TRAK Type 9127-SL(CW) Microwave Cavity is ideal as a local oscillator or low power transmitter in the new 2.2—2.3 KMc telemetry band. With a power output in excess of 100 mw, it is also suitable for use as a parametric pump, or the energy source for harmonic generators.

Specifications are:

Frequency	Tunable 2.15—2.45 KMc
CW Power Out	Greater than 50 mw over entire tuning range Greater than 100 mw over 2.2—2.4 KMc range
Power Input	150 VDC at 10 ma and 6.5 V at 240 ma
Temperature Stability	Less than 1 Mc drift with a temperature variation of 80°C. Operable from −70° to +120°C.
Size	1" diameter by 4¾" long
Weight	7 ounces

TRAK MICROWAVE has miniature CW Oscillators with output power of 10 mw to 2 watts at frequencies between 800 and 7000 Mc. Also, Oscillators engineered to your specifications!

Write today for **new** Catalog 61A, full of oscillators for CW, grid pulse and plate pulse service.



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Circle Reader Service Card 102

IRE Booths

(*Continued from page 149*)

eight or 10 foot sizes for 806-960 Mc, and 1700 to 2700 Mc.

In the 2000 Mc band, dual polarized feeds are offered. In the 5925 to 8500 Mc band, button hook feeds are offered for plane polarization, while dual polarization feeds are also available.

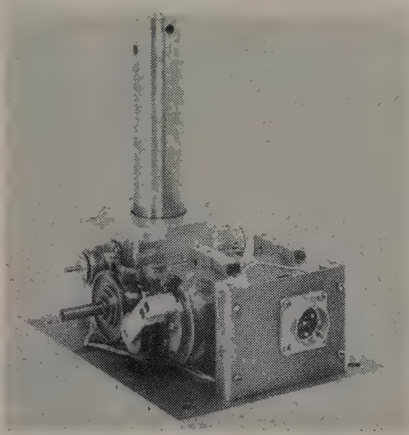
Circle Reader Service Card 148

—*mwj*—

AMERICAN ELECTRONICS BOOTH 1327

Featured in the American Electronics, Inc., Los Angeles, Cal., display at the IRE Show will be AEI's new eight millisecond response electric servo actuator for the control of flight surfaces of missiles.

Utilizing a constant speed miniaturized motor as its source of motion, and a new clutch developed by American Electronics to give left or right action, each flight control surface is directly connected to its own actuator.



Weight savings of as much as 50 per cent over hydraulic systems for the actuation of control surfaces are claimed by American Electronics, Inc., in addition to the total elimination of piping, valves, filters, linkages, accumulators and other plumbing accessories.

Shelf life without maintenance is infinite, since there are no seals, fluids or other elements in the actuation system that can deteriorate.

Circle Reader Service Card 149

—*mwj*—

QUAN-TECH LABORATORIES, INC.

A new, compact Amplitude-Distribution Analyzer, designated Model 317, is announced by Quan-Tech Laboratories, Inc., Boonton, N. J. The new unit will be introduced at the IRE Show.

Model 317 establishes the amplitude-probability distribution of random signals, and is useful for determining threshold requirements, error or false alarm probabilities, etc. A voltage "threshold" level is preset by a front panel control; noise levels exceeding the preset voltage level are read, or monitored, by a scale calibrated in percentage — referred to time.

(*Continued on page 156*)

MAX-IMUM MINIATURIZATION

ACF ELECTRONICS C-BAND MICROWAVE COMPONENTS

System-tested in operational space vehicles. Engineered to meet complete military missile specifications.

CW LOCAL OSCILLATOR
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Tuning Range: 500 MC
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Stability: ± 3 MC over all military environmental conditions

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March 20-23

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2-WATT L-BAND
TRAVELING WAVE TUBE AMPLIFIER

WAVE PARTICLE

The model 560-L is a typical example of traveling wave tube amplifiers manufactured by Wave Particle. This instrument is one of forty various models covering most requirements for low, medium, and high power wave tube amplifiers. In addition to standard amplifiers, a series of special low noise preamplifiers are available from 1.0 to 18.0 gc. With noise figures in the 3 db. to 10 db. range. A complete line of electronically swept signal sources are also available and may be used in conjunction with T.W.T. amplifiers. Wave Particle would welcome the opportunity to quote on your special requirement for wave tube or similar exotic microwave instrumentation.

See us at the New York I.R.E. Show, Booth M-23.

For more details on amplifiers and signal sources please contact your Wave Particle

SALES ENGINEERING REPRESENTATIVES

MODEL 560-L
AT NEW REDUCED PRICE

Frequency:	1.0-2.0 gigacycles
Power Output:	2.0 watts (minimum)
Gain:	30 db. (minimum)
Noise Figure:	35 db. (nominal)
T.W.T. Type:	Sylvania 10100
Panel Space:	7 inches x 19 inches
Delivery:	Three weeks
Price:	$2,250

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look into Panoramic's new SPA-4a exclusive features for more reliable spectrum analysis 10 mc to 44,000 mc

2 to 4 TIMES THE USABLE SENSITIVITY

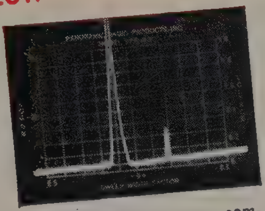
Lower internal noise enables analysis of even smaller signals than before (see chart) . . . accurate measurement of more highly dispersed energies, as typified by extremely narrow pulsed signals.

BAND	RF SENSITIVITY*
1- 10 – 420 MC	–100 to –110 dbm
2- 350 – 1000 MC	– 95 to –105 dbm
3- 910 – 2200 MC	–100 to –110 dbm
4- 1980 – 4500 MC	– 90 to –100 dbm
5- 4.5 – 10.88 KMC	– 90 to –100 dbm
6- 10.88 – 18.0 KMC	– 85 to –100 dbm
7- 18.0 – 26.4 KMC	– 70 to – 90 dbm
8- 26.4 – 44.0 KMC	– 60 to – 85 dbm

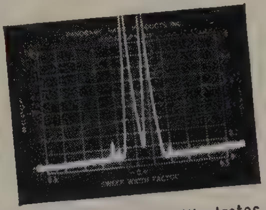
*measured when signal and noise equal 2x noise

EXCEPTIONALLY LOW DISTORTION

Reduced threshold allows SPA-4a to operate at smaller input signal levels (and attenuated larger ones). Unretouched screen photos show how this permits virtually spurious-free measurement—over a wide dynamic range—of harmonics, in-band distortion, and other weak signals in the presence of strong ones.



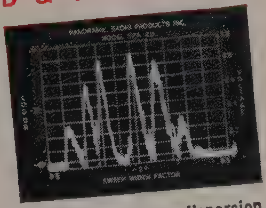
Extended dynamic range comparison of 2 signals on SPA-4a. Larger is + 15 db over full scale log. Smaller is at –28 db on scale or –43 db from larger. Note exceptional freedom from spurious. (Photo not retouched)



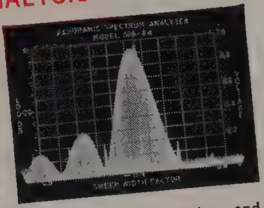
Distortion analysis illustrates SPA-4a wide range linearity. Odd-order distortion here is measured more than 50 db below level of 2 main tones (deflected 20 db above full scale). Photo unretouched.

HIGHLY RESOLVED & CALIBRATED ANALYSIS

Reduced internal hum improves resolution of closely spaced signals; also improves minimum dispersions for more highly magnified analyses. Marker modulation permits highly accurate measurements of frequency differences during high speed analysis. See photos.

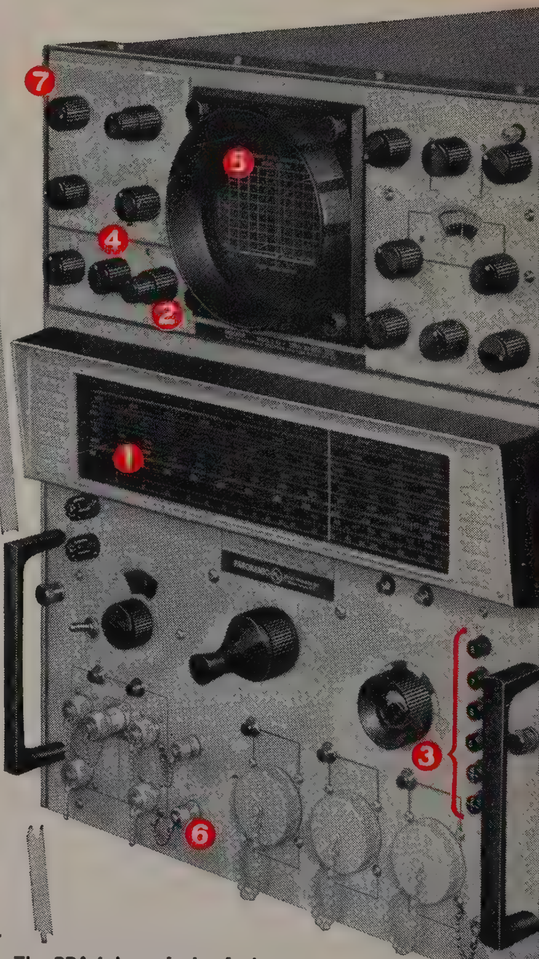


Narrow band 20 kc dispersion analysis shows unique resolution capability. Here, a 1000 mc FM signal with 2 kc modulation is seen near first carrier null. Photo unretouched.



Pips of internal marker and sidebands (ext. mod.≈100 kc) accurately measure pulse width in spectrum of 10μs. radar pulse. Upper lobes seen to be very small. (Unretouched)

dependable
CERTIFIED
SPECIFICATIONS
for accurate data



Important as these advantages are, there are many more.

The SPA-4a's exclusive features also include:

1. **ONE TUNING HEAD** — 10 mc to 44,000 mc, utilizing 3 stabilized, low hum local oscillators (1 HF triode and 2 klystrons). Fundamentals to 11 kmc. Direct reading with ± 1% accuracy.
2. **TWO INDEPENDENT FREQUENCY DISPERSION RANGES** Continuously adjustable; 0-70 mc with exceptional flatness, stable 0-5 mc for narrow band analysis. Both swept local oscillators operate on fundamentals only for spurious-free analysis.
3. **PUSH-BUTTON FREQUENCY RANGE SELECTOR.**
4. **ADJUSTABLE IF BANDWIDTH 1 KC to 80 KC.**
5. **3 CALIBRATED AMPLITUDE SCALES** — 40 db log, 20 db lin, 10 db power.
6. **SYNCHROSCOPE OUTPUT WITH 40 DB GAIN.**
7. **SWEEP RATE ADJUSTABLE FROM 1-60 CPS.** May be set free running, synchronized to the line or to external prf. Also provisions for sweep rate calibrations

Easy to use, too . . . human engineered for simple operation, component accessibility.

The advanced new SPA-4a is unmatched for visually analyzing FM, AM and pulsed signal systems —instabilities of oscillators —noise spectra—for detection of parasitics—studies of harmonic outputs, radar systems and other signal sources.

Write, wire, phone today for detailed SPA-4a specification bulletin and new Catalog Digest.

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Abstracts from *Russian Technical Literature*... of interest to microwave engineers

Translations of complete papers are available at nominal cost from Morris D. Friedman, Inc., c/o "the microwave journal," 1330 Beacon Street, Brookline, Massachusetts. Prices are dependent upon length of paper.

IVUZ, RF, 3(1): 97-101 (1960)
V. B. Gil'Denburg; M. A. Miller:

ON THE ACCELERATION OF A PLASMA BUNCH DURING PASSAGE THROUGH AN INHOMOGENEOUS ELECTROMAGNETIC FIELD.

The non-relativistic motion of a plasma bunch in a slightly inhomogeneous variable electromagnetic field is considered. A general expression has been obtained for the average force due to field interaction with the electric dipole moment of the bunch and the possibilities are estimated of accelerating a bunch in traveling and standing wave fields. It is shown that "multistage" acceleration in systems with alternate domains of a slightly and strongly inhomogeneous field is difficult because of bunch "sorting" according to polarization and velocity.

NIRFI (*8R*)

— m w j —

IVUZ, RF, 3(1): 102-109 (1960)
V. A. Berbasov; M. I. Kuznetsov; V. E. Nechaev:

INVESTIGATION OF FLUCTUATIONS

Results are presented of an experimental investigation of the spectrum of the plate current fluctuations of a magnetron in the extra-critical region. The spectrum of the plate current fluctuations has a number of quite evident maxima due to the intrinsic oscillations of the magnetron space charge which are incoherently excited by the fluctuating currents. In addition to the maxima at frequencies close to those described by the Hartree relation (oscillations of the rotating wave type) there is a maximum in the spectrum near the cyclotron frequency, which is due to oscillations of axisymmetric type.

NIRFI (*4F, 1T, 8R*)

— m w j —

IVUZ, RF, 3(1): 155-158 (1960)
V. N. Shevchik; L. D. Pokrovskii:

ENERGY EXCHANGE IN THE DISCRETE INTERACTION OF ELECTRONS WITH A TRAVELING ELECTROMAGNETIC WAVE.

"The analysis of cascade interaction between electrons and waves of constant amplitude under the assumption of small transit angles through the interaction region is extended to the case when the relation between the extent of the high-frequency interval and the length of the space separating adjacent gaps can be arbitrary."

SARATOV UNIV. (*2F*)

— m w j —

IVUZ, RF, 3(2): 257-268 (1960)
N. M. Tseitlin:

ON THE QUESTION OF ANTENNA INTRINSIC NOISE AND EFFICIENCY

On the basis of the theory of thermal radiation [1-4] and the theory of thin antennas [5, 6], expressions are obtained for the spectral density of the intrinsic noise of a dipole and passive elements of a load-matched antenna. Appropriate expressions are presented for the efficiency and numerical values of the antenna temperature due to thermal radiation of the metal dipole and mirror; a formula is obtained for the spectral density of the emf in the antenna from the thermal radiation of heated bodies.

NIRFI (*1F, 2T, 10R*)

— m w j —

IVUZ, RF, 3(2): 269-275 (1960)
V. M. Sedykh, A. F. Zorkin:

WAVEGUIDE WITH CROSS-SHAPED TRANSVERSE ACTION.

On the basis of solving the field equations, formulas are obtained to determine the critical frequencies of lower order modes in a cross-shaped waveguide and the limiting power for the fundamental H_{10} mode is also found. Results are presented of an experimental verification of the formulas obtained.

KHAR'KOV UNIV. (*3F, 6R*)

— m w j —

IVUZ, RF, 3(2): 276-284 (1960)
G. I. Friedman:

ELECTROMAGNETIC SHOCKWAVES IN A STRIP-WAVEGUIDE FILLED WITH A FERRITE.

The shockwave structure in a strip waveguide filled with a saturation-magnetized ferrite is analyzed by successive approximations.

NIRFI (*3F, 6R*)

— m w j —

IVUZ, RF, 3(2): 290-298 (1960)
V. A. Berbasov; M. I. Kuznetsov; V. E. Nechaev:

INVESTIGATION OF FLUCTUATIONS IN A MAGNETRON. II. AZIMUTHAL CURRENT FLUCTUATIONS.

Basic regularities, to which the spectrum of fluctuations in a magnetron in the pre-oscillation region is subject, are established. It is shown that the spectrum of the azimuthal current fluctuations on the anode surface has maxima near the frequencies corresponding to the Hartree threshold relation and that the incoherent space charge oscillations being observed in the magnetron are its intrinsic oscillations excited by the fluctuating currents.

NIRFI (*5F, 13R*)

— m w j —

IVUZ, RF, 3(3): 351-366 (1960)
V. V. Vitkevich; L. I. Matveenko:

RADIO IMAGE OF THE SUN AT 3 CM.

New observations of the radio emission of the sun have been carried out at a 3.2 cm wavelength on the 31 meter fixed radio telescope of the Crimean Scientific Station of the FIAN (Physics Institute, Acad. of Science). "Radio images" of the sun have been obtained; a close connection has been established between the regions of elevated radio-emission intensity at 3 cm and 21 cm wavelengths; it is shown that the regions of elevated radio-emission intensity in the 1.5 - 21 cm wavelength band are optically fine in the majority of cases. Data have been compiled on the displacement of the effective center of emission of the sun at 3 cm and 1.5 cm wavelengths. Data are presented on the "shape" of the sun at 3 cm.

Polarization measurements made at the 3.2 cm wavelength disclose the presence of circular polarization over the individual regions of elevated intensity.

FIAN USSR (*12F, 8R*)

— m w j —

IVUZ, RF, 3(3): 405-418 (1960)
S. A. Akhmanov; G. F. Antonov:

AMPLITUDE FLUCTUATIONS IN A PULSE GENERATOR WITH A REFLEX KLYSTRON.

Results are presented of an experimental investigation of the amplitude fluctuations in a pulse generator with a reflex klystron. Special attention has been paid to the statistical characteristics of the amplitude for the oscillation build-up region in an autonomous reflex klystron. Certain results are also presented which characterize the oscillation build-up process in a klystron, "sub-excited" by a sinusoidal external force.

MOSCOW UNIVERSITY (*7F, 14R*)

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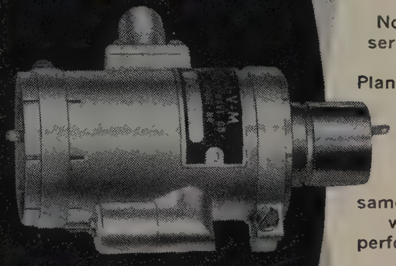

Now, J-V-M offers a new series of exceptionally rugged, economical Planar Triode Cavities for commercial and military quantity production use—the Universal "10" Series built to the same rigid standards and with the same reliable performance of the popular Mercury "10" Series.

Precision engineered

A complete range of cavities in frequencies from 220 to 4300 MC, in pulse and CW units—offering design flexibility and outstanding performance.

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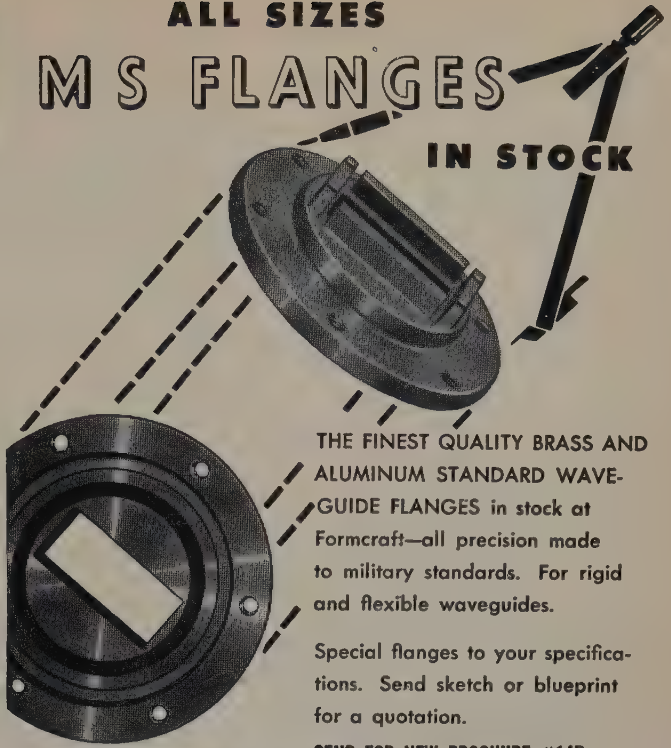

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Special flanges to your specifications. Send sketch or blueprint for a quotation.

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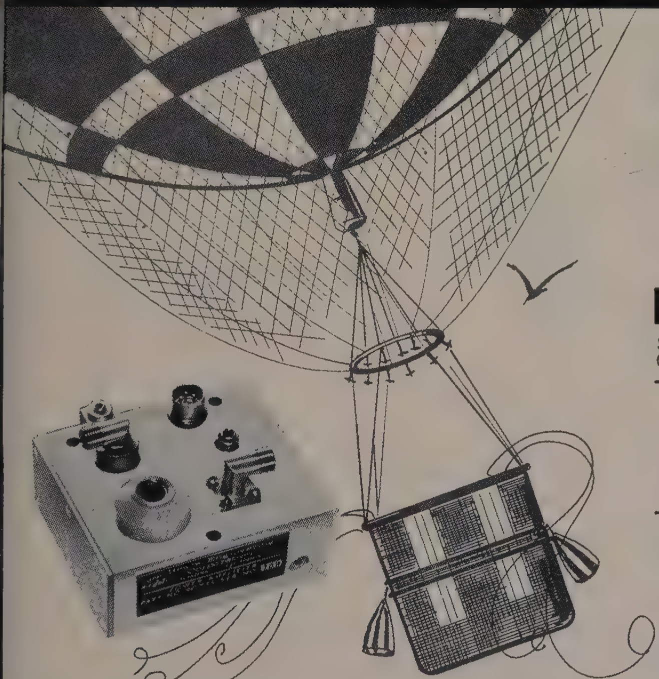

P-20 4W POWER AMPLIFIER
VOL. (8.6 in.^{3}) WT. (9 oz.)

GOING UP?

THIS SERIES OF MINIATURE L & S BAND AMPLIFIERS IS DESIGNED FOR SPACE FLIGHT* 1961 STYLE.

YOU WON'T WAIT 80 DAYS FOR DELIVERY BY BALLOON. CURRENT DELIVERY IS 21 DAYS OR LESS ON STANDARD UNITS.

SPECIFICATIONS	20 SERIES L AND S BAND CAVITY AMPLIFIERS UTILIZING GL6442 CERAMIC — METAL PLANAR TRIODES			
MODEL	TYPICAL GAIN IN db @ 215 to 1100 mc	BANDWIDTH IN mc (TYPICAL)	POWER OUTPUT @ 215 to 1100 mc	POWER REQUIREMENTS PLATE
A-20	15	6	1w	250v @ .025a
P-20	8	7	4w	250v @ .035a

DESCRIPTION: A-20 is a high gain amplifier; P-20 is a power amplifier. Heater supply is 6.3v @ .9a for both units.

VIBRATION: 0.3 inch D.A. or a vector sum of 15g (whichever is less) transverse and longitudinal from 5 to 2000 cps.

These characteristics may be varied within moderate limits to apply to special customer requirements.

*ALSO IDEAL FOR GROUND SUPPORT

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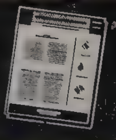


Circle Reader Service Card 107

IRE Booths

(*Continued from page 151*)

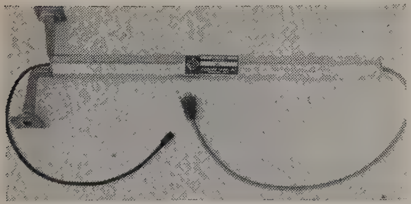
The fully transistorized Model 317 operates over a frequency range from five cps to 0.5 Mc. Amplitude ranges are 100 per cent, 10 per cent and one per cent full-scale. Accuracy is ± three per cent full scale.

Both normal and inverted operation are possible for greater accuracy in reading small percentage values. An output to drive a counter is available at a front-panel BNC connector. Size of the unit is 8¼ inches x 5 inches x 6¾ inches; weight is five lbs.

Circle Reader Service Card 150

—*mwj*—

HUGGINS LABORATORIES, INC.
BOOTHS 2925-26



Huggins Laboratories, Inc., Sunnyvale, Cal., will introduce eight new Traveling Wave Tubes at the 1961 IRE Show.

Brief specifications of several are as follows:

HA-82 — 10 to 20 kMc frequency range, solenoid focused broadband TWT amplifier with one mw min. power output, and 25 db min. small-signal gain.

HA-86 — .5 to one kMc, solenoid focused, low-noise amplifier with seven db max. noise figure, and 25 db min. small-signal gain.

HA-70 — 2.3 to 3.5 kMc, solenoid focused, low-noise amplifier with seven db max. noise figure, and 30 db min. small-signal gain.

HA-63 — one to two kMc, electrostatically focused, TWT amplifier, with one watt min. power output, and 30 db min. small-signal gain.

HA-61 — seven to 14 kMc, solenoid focused, low-noise amplifier, with 15 db max. noise figure, and 25 db min. small-signal gain.

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—*mwj*—

ESC ELECTRONICS CORP.
BOOTH 2915

ESC Electronics Corp., Palisades Park, N. J., manufacturers of delay lines, filters, pulse transformers and other types of video networks, announces the first of a new series of miniaturized delay lines — Model 37-74, with a delay time/rise time ratio of better than 40/1 in a case size less than 3½ cu. in.

Circle Reader Service Card 152

—*mwj*—

MENLO PARK ENGINEERING
BOOTH 3843

Menlo Park Engineering, Menlo Park, Cal., announces a new UHF electronically swept oscillator, the Model 400 cov-

ering the frequency range of 500 Mc t 1100 Mc.

Output frequency is read directly from the frequency dial calibrated to ± one per cent of reading. Sweep-width is continuously adjustable and read on a direct-reading meter.

The unit is capable of amplitude, pulse or frequency modulation. Internal square wave (400 to 1200 cps) is provided for ease in making reflectometer, slotted line and antenna measurements. Sweep rates are adjustable from .01 to 100 cps for display on an oscilloscope or a mechanical recorder.

The new Model 400 Oscillator will be demonstrated for the first time at the 1961 IRE Show.

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—*mwj*—

M | S

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RDA-11	2x1	8-32x .625"	4.125	.800	15.00
RDA-12	1½x¾	6-32x .500"	3.125	.600	13.00
RDA-13	1¼x⅝	4-40x .500"	2.500	.474	11.00
RDA-14	1x½	4-40x .375"	2.00	.380	11.00
RDA-15	.702x.391	4-40x .312"	1.500	.300	11.00
RDA-16	½x¼	2-56x .250"	1.125	.156	11.00

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EW LITERATURE

CATALOG DIGEST SUMMARIZES PANORAMIC INSTRUMENT SPECIFICATIONS

A new 12 page Catalog Digest "E", mmarizing the specifications and applitions of more than 60 Panoramic test struments, is now available from Panomic Radio Products, Inc., Mt. Vernon, . Y.

Information on the latest developments Panoramic Spectrum Analyzers, Freiency Response Plotters, Communicaons Systems Analyzers and Telemetry est instruments designed and manufacired by the firm is included in the Catalog igest. Frequency range of these instruents is from 1/2 cps through 44,000 Mcs.

An unusual highlight of this short-form atalog is the liberal use of block diarams indicating typical application setps of Panoramic instruments in combinaon with users products. These diagrams gether with summaries of specifications, hotographs of the instruments and typical reen displays provide the reader with a nvenient and succinct guide.

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—*mwj*—

PRD OFFERS BULLETIN ON WAVEGUIDE AND COAXIAL ATTENUATORS

A four page, three color, Bulletin 500 vailable from PRD Electronics, Inc., rooklyn, N. Y., manufacturer of microvave and electronic test equipment, desribes microwave waveguide and coaxial ttenuators.

Featured are fixed and variable waveuide and coaxial attenuators, including Iil Spec (ruggedized), precision dial, recision gauge, level set, and variable utoff types.

Charts and photographs indicate freuency, attenuation, VSWR, dimensions nd length.

Circle Reader Service Card 159

—*mwj*—

(*Continued on page 160*)

Visit the staff of
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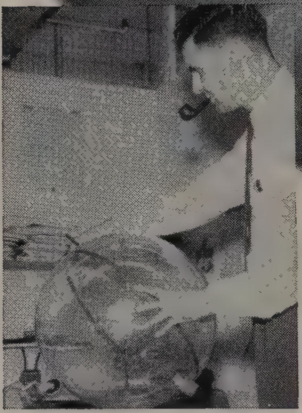

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Whether or not you've had specific experience in space electronics, you may be able to go right to work at MSVD on some of the most sophisticated and technologically exciting projects in the entire space field—from ICBM re-entry vehicles to operational space craft.

The work here is at the very edge of the state of the art, transforming the latest research discoveries into workable engineering solutions. You'll be concerned with new advances in plasma physics, thermoelectric phenomena, telemetry... with radical new requirements in micro-miniaturization, space to weight reductions, performance efficiency... with an entirely new order of reliability specifications to assure systems' operation in space for a year or longer.

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Inquiries are invited from electronics engineers who are technically advanced in their own discipline, and are deeply interested in the related fields of space vehicle development. Write informally, or forward your resume to: D. G. Curley, Div. 127 M

MISSILE & SPACE VEHICLE DEPARTMENT

GENERAL ELECTRIC

3198 Chestnut Street, Philadelphia 4, Pennsylvania

Said Gaspard de Coriolis: *"A particle which is subject to no forces in a rotating coordinate system experiences a radial acceleration and a tangential acceleration."*

It was around 1840 that Coriolis discovered what has since become known as the Coriolis Effect. He noticed objects above the earth tend to rotate relative to the earth's rotation . . . to the right in the northern hemisphere, to the left in the southern.

The Coriolis Effect is in force in outer space, too. If a space vehicle is rotated in order to establish artificial gravity, the necessarily short radius of the rotation causes a Coriolis force. This creates orientation problems for a human occupant. To eliminate this difficulty, a scientist at Lockheed Missiles and Space Division conceived the idea of connecting the vehicle to an auxiliary fuel tank by a half-mile-long cable. Thus, if the whole system is then rotated at a reduced speed around its center of mass gravity, the longer radius greatly minimizes the Coriolis force. Right now—on the drawing boards at Lockheed—is an enormously advanced space vehicle system which utilizes this concept, in addition to many others.

Fortunately, natural laws are about the only restrictions which circumscribe scientists and engineers at Lockheed Missiles and Space Division. The climate in Sunnyvale and Palo Alto, on the San Francisco Peninsula, is close to perfection. The creative atmosphere—the opportunity to work on such important projects as the DISCOVERER and MIDAS satellites, the POLARIS FBM, or even more advanced concepts such as the space system cited above—is the dream of the creative engineer.

Why not investigate future possibilities at Lockheed? Write Research and Development Staff, Dept. M-11C, 962 West El Camino Real, Sunnyvale, Calif. U.S. citizenship or existing Department of Defense industrial security clearance required.

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New Literature

(*Continued from page 157*)

ENGINEERING DATA ON TEMPERATURE COMPENSATED CUP CORES AVAILABLE

A new engineering bulletin on specification No. TC1-01, a ferramic cup core assembly, is available from General Ceramics, Keasbey, N. J.

These temperature compensated cores are used in telephone carrier filters, delay lines and other electronic coil applications requiring exacting temperature stability. The bulletin includes physical dimensions, electrical characteristics and typical "Q" curve.

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—*mwj*—

EQUIPTO ELECTRONICS OFFERS BROCHURE ON ITS ENCLOSURE SYSTEM

A new four color eight page brochure has been issued by Equipto Electronics Corp., Naperville, Ill.

This brochure illustrates some of the basic frame structures in the Equipto Enclosure System.

Also described and illustrated are outstanding features of these modular enclosures for the electronic and instrumentation field.

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—*mwj*—

(*Continued on page 163*)

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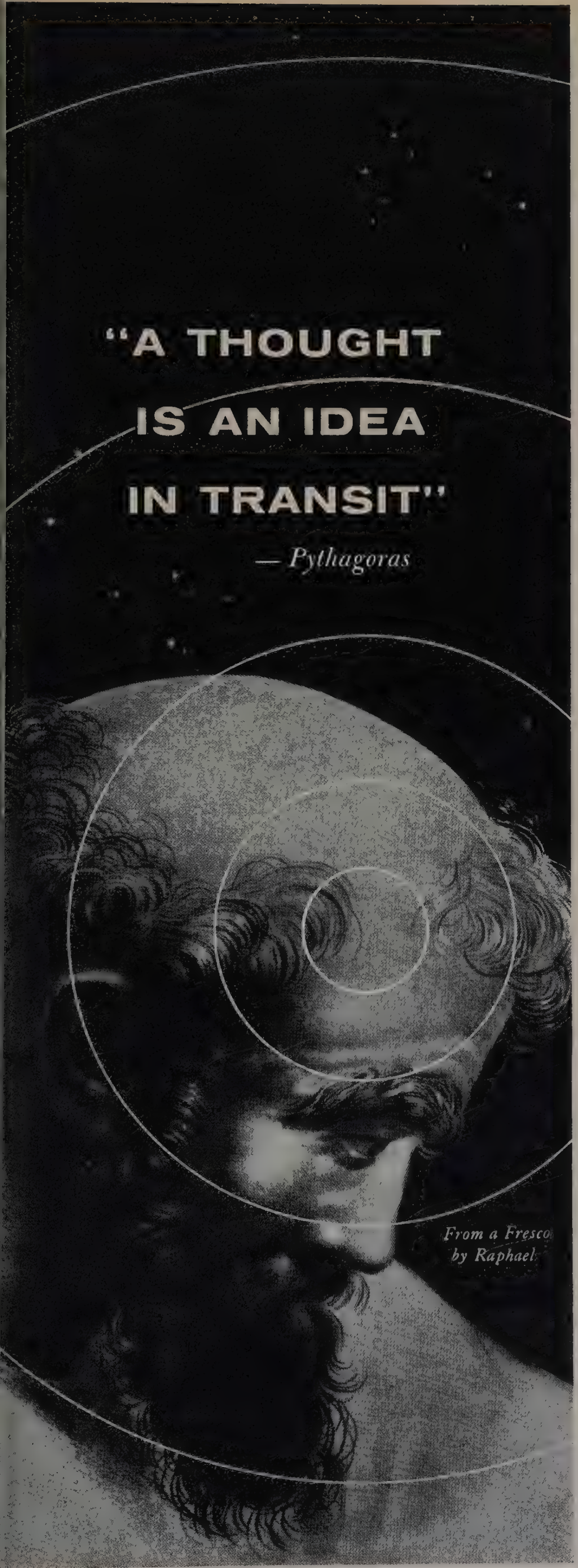
"A THOUGHT IS AN IDEA IN TRANSIT"
— Pythagoras

From a Fresco by Raphael

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AC Spark Plug • The Electronics Division of General Motors
Milwaukee, Wisconsin • Los Angeles, California • Boston, Massachusetts

New Literature

(*Continued from page 160*)

MICROLAB CATALOG DESCRIBES MICROWAVE COMPONENTS

Microlab, Livingston, N. J., has made available a new catalog of microwave components consisting of 72 pages and including detailed descriptions and specifications of its line of coaxial attenuators, filters, power dividers, terminations, crystal mounts, tuners and other coaxial microwave components.

A large amount of space in this catalog is devoted to design sections for each product which present technical information of a general nature to assist the design engineer in the selection of the proper component. Also included is a special article on "The Application of Matrix Algebra to the Design of Microwave Networks."

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—*mwj*—

INVAR CATALOG PROVIDES TRANSISTORIZED POWER SUPPLY SPECIFICATIONS

Power Supply Catalog No. 401 is now available from Invar Electronics Corp., Pasadena, Cal. This new descriptive literature shows, in easy-to-read form, all electrical and mechanical specifications of Invar's 53 standard transistorized power supplies.

Several new models are shown and improved specifications are listed for many of the proven Invar standards.

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—*mwj*—

SEMICONDUCTOR DIODE DATA/FILER OFFERED BY MICROWAVE ASSOCIATES

A functional Data/filer folder designed for convenience in cataloging Engineering Standards Data Sheets on Microwave Associates' microwave video, mixer, special purpose, Varactor, and high-speed computer diodes is available from Microwave Associates, Inc., Burlington, Mass.

The new Data/filer is a file folder also punched so that it may be used in either file or in any standard ring-binder as desired. Individual data sheets on Microwave Associates' newest diodes with electrical and mechanical characteristics and featuring application suggestions and operation curves are included with the Data/filer.

As new Engineering Standards Data Sheets are available they will be mailed to holders of the Microwave Associates' Data/filer.

Included with the Data/filer for initial distribution are Engineering Standards Data Sheets on Microwave's new "Pill" Varactor series; new high voltage Varactors; high cutoff frequency reversible cartridge Varactors, and six subminiature glass-case video detector and mixer diodes recently introduced by Microwave Associates (1N830, 1N831, 1N832, and 1N833 series).

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- Sr. ENGINEER with Klystron design or manufacturing experience.

Write or send resume to: Mr. William Kacala, Technical Recruiting
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or phone collect Elmira, REgent 9-3611

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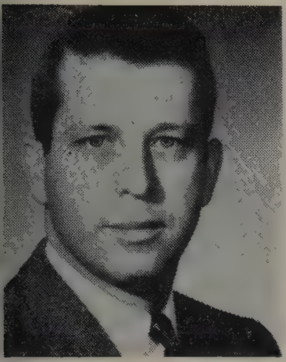
" EACH YEAR THE NUMBER OF MICROWAVE PAPERS SUBMITTED TO THE IRE CONVENTION HAS DECREASED . . . "



Microwaves and the IRE International Convention

SEYMOUR B. COHN, ASSOCIATE EDITOR, *the microwave journal*

Once again we are in the month of radio engineering's greatest annual gathering, the IRE International Convenion in New York. Each year the radio industry's dynamic growth has resulted in a larger show of products, bigger crowds, and more recognition from the press.

As evidence of microwave's faster growth than most other segments of the radio industry, the number of microwave exhibits has increased in greater proportion han the rest of the show. The present and future appear prosperous for radio engineering in general, and particularly so for microwaves.

One part of the Convention has not grown in recent years — the technical paper sessions. Since 1955 the number of technical sessions has been constant at 54 or 55. Evidently this number of sessions represents saturation —radio engineers no matter how dedicated can cope with no more.

What has microwave's share of the technical sessions been since this saturation set in? Have we held our own against the challenge of other vigorous parts of the radio engineering field? The truth is we have not. In 1955 here were four sessions relating to microwave theory and techniques, two microwave antenna sessions, and one microwave tube session — seven microwave sessions n all. In 1956 and 1957 there were six microwave sessions each year. In 1958 to 1960 there were five sessions. At this writing I have not yet seen the entire program for 1961, but I have been told that there will be two microwave theory and techniques sessions and one microwave electronics session. If the program will also include two microwave antenna sessions, we will be merely even with our record of the past few years.

Radio engineering's second greatest convention, WESCON, has a similar record. In 1956 there were eight WESCON technical sessions devoted to microwave theory and techniques, antennas, and tubes, while in 1960 there were only five. Thus, at the two major radio engineering shows, our microwave field does not seem to be holding its own.

The explanation for the above trend is, of course, the rise of IRE Professional Group Symposia. In the past half-dozen years, PGMTT, Electron Devices, and Electromagnetic Symposia have grown to major proportions. The total microwave papers presented each year at all conventions and symposia have increased sharply. Thus, the shrinkage of the microwave program at the IRE Convention is not a sign of obsolescence, but rather it is evidence that the majority of authors prefer to present their work at professional group symposia.

But why has this preference developed? As an occasional author myself, I will give my own answer to this question. The sheer size and circus nature of the IRE Convention provide too many distractions for an attendee's attention. The author must compete with exhibits, committee meetings, social events, sales representative suites, and field trips. Furthermore, he must compete with a multiplicity of parallel technical sessions. He cannot be certain whether or not a substantial number of his technical peers will be present and listening attentively to the results of his work.

On the other hand, meetings such as the PGMTT Symposium offer an ideal environment for the author. Everything there is planned to aid and enhance communication between the author and the audience. The atmosphere is professional rather than commercial. There are no competing events, and no parallel sessions. The result has been immediate popularity with authors and audience alike.

This then is the situation, and a reasonable explanation for it. The question now is, should we be concerned and take some steps to change it? In my opinion, the rise of professional group symposia to dominance in the technical paper area is a healthy development, and not to be combated. On the other hand, the technical program is a basic, essential part of the IRE Convention. Although other aspects of the IRE Convention compete for audience and prestige, the Convention as a whole could not exist without it. My belief is that the technical program gives the Convention purpose and stature, and that a mere exhibit of product could not alone sustain interest over

COHN

(*Continued from page 167*)

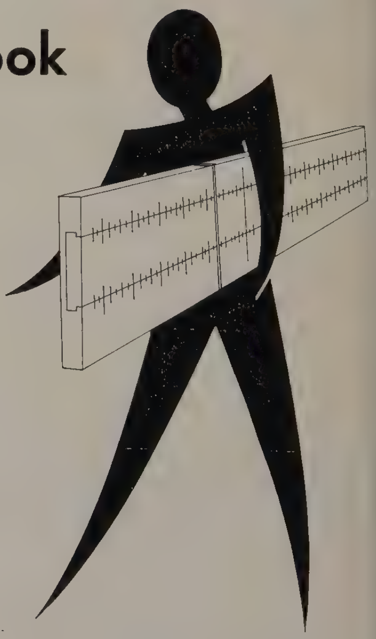
the years. For the Convention to be a success (and of course, it should be a success) a strong technical program must be part of it.

There is an illuminating contrast between meetings of the technical program committee of the IRE Convention and of the PGMTT Symposium. Each year the number of microwave papers submitted to the IRE Convention has decreased, until it has become difficult to assemble a good program. Meanwhile, the PGMTT Program Committee has become swamped with papers, and is forced to reject many excellent offerings. The PGMTT Symposium schedule is now saturated, unless more days are added, or multiple sessions are introduced. Both of these alternatives are undesirable, and I advise strongly against them. Thus, the IRE Convention and WESCON are again needed as stages for technical presentations. I would recommend that authors consider the major conventions seriously when planning their future offerings.

Also, I feel that the Convention management should take steps to strengthen the technical program's competitive position against distracting parts of the show. For example, the situation would be improved for our field if the microwave sessions were held at the Waldorf-Astoria instead of at the Coliseum. The crowds, noise, confusion, and carnival atmosphere of the Coliseum are detrimental to serious concentration. A calmer, more professional atmosphere would certainly help restore the stature of our technical program.

Another positive step would be to decrease the interval between submission and presentation of the paper. This year authors were required to meet a deadline five full months in advance of the Convention. Such a long lead time discourages papers on fresh research. An author who believes he has something original to say wants to say it promptly, while it is still new, and before it is said by someone else. I am sure that if the lead time were reduced by at least one month, the results would be most beneficial.

This year let us enjoy the excitement of the IRE Convention and Show, the cocktail party, the banquet, old friends, the city. But let us hope that next year and later years will see greater vitality added to the technical program and a strengthening of professional values.



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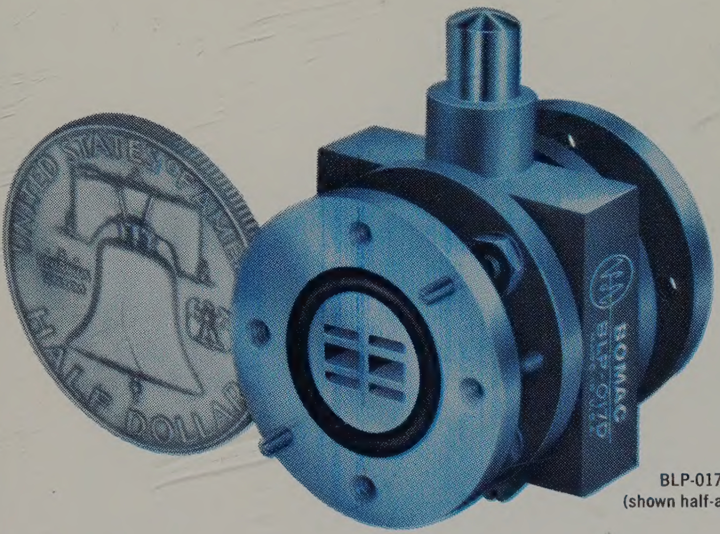

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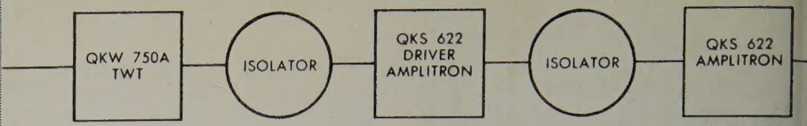

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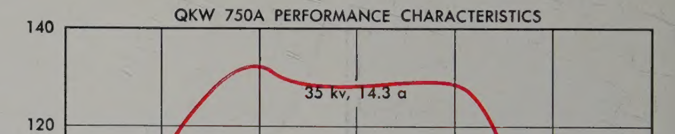

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